PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. VI. 1866–67. No. 73.

Monday, 18th February 1867.

SIR DAVID BREWSTER, President, in the Chair.

The following Communications were read:—

1. On an Application of Mathematics to Chemistry.

By Dr A. Crum Brown.

In this paper chemical substances are represented as "operands," and chemical processes as "operators"—thus, $\phi \cdot x$ is the substance produced by acting on the substance x by the process ϕ. When ϕ, χ, ψ, &c., act independently on x, this is indicated by the notation $\left.\begin{matrix}\phi\\ \chi\\ \psi\\ \&c.\end{matrix}\right| \cdot x$. When they act one on another to produce a complex operator which acts on x, the notation $\phi \cdot \chi \cdot \psi \cdot x$ is used. It is shown that in the latter case the commutative law does not apply to operators.

The meaning of the negative index applied to an operator is defined thus: $\phi \cdot (\phi^{-1} \cdot x) = x$; and it is shown that $\phi^{-1} \cdot x$ may have more than one value. $\left.\begin{matrix}\phi\\ \phi\end{matrix}\right| \cdot x$ is written $\phi^{2)} \cdot x$, and generally $\left.\begin{matrix}\phi^{m)}\\ \phi^{n)}\end{matrix}\right| \cdot x = \phi^{m+n)} \cdot x$ where m and n are both positive or both negative $\left(\left.\begin{matrix}\phi\\ \phi\end{matrix}_{-1}\right| \cdot x \text{ not being necessarily } = x\right)$. $\phi \cdot \phi \cdot x$ is written $\phi^2 \cdot x$, and generally $\phi^n \cdot \phi \cdot x = \phi^{n+1} \cdot x$.

The general series $x, \phi \cdot x, \phi^2 \cdot x, \phi^3 \cdot x \cdots\cdots \phi^n \cdot x$ is shown to include the case of homologous series, and the essential difference between this series and x, $\phi \cdot x$, $\phi^{2)} \cdot x$, $\phi^{3} \cdot x \cdots\cdots \phi^{n)} \cdot x$ is pointed out.

2. Notice of an Easy Method of Preparing Nitroprussides. By Dr Lyon Playfair, F.R.S.

Since I described the method of making nitroprussides by the action of nitric acid on yellow prusside of potassium, Hadow (Chem. Soc. Journal, 1866) has given a more productive process, by treating potassic ferridcyanide with an equivalent quantity of mercuric chloride, of sodic nitrite, and of acetic acid. Hadow contends that N_2O_3 substitutes Cy_2 in this reaction, instead of NO as supposed by me. I am still of opinion that the formula of nitroprussides is $FeCy_5\ NOM_2$. For if an equivalent quantity of an acid be added to a solution of potassic ferridcyanide, and a stream of NO be passed through this solution, at a temperature of between 70° C and 80° C, nitroprusside is slowly but abundantly formed, with the evolution of hydrocyanic acid.

$$FeCy_6K_2H + NO = FeCy_5NOK_2 + HCy.$$

In these experiments every care was taken to remove all traces of a higher oxides of nitrogen. But this process is not productive, and is only interesting as showing that NO can substitute Cy.

After various experiments, I found the following simple process to yield excellent results:—Equal weights of potassic ferridcyanide and of crystallised tartaric acid are dissolved separately in the smallest quantity of cold water. One-half of the solution of tartaric acid is then mixed with the solution of ferridcyanide and briskly stirred, the clear liquid being decanted from the precipitated cream of tartar. A standard solution of sodic nitrite* having been determined beforehand, a quantity, corresponding to one equivalent for each equivalent of the potassic ferridcyanide used, is now divided into two parts. One-half of this solution is added to the cold mixture as above described, and immediately after the remaining half of the solution of tartaric acid, and a solution of one equivalent of chloride of sodium. These cause a further precipitation of potassic bitartrate. A slight effervescence now ensues; and from the insoluble precipitate giving points of escape for the nitrous acid, a good deal would be lost. The clear solution is, therefore, rapidly decanted from the precipitate, and the latter is thrown on a filter to drain. The mixture is now heated up as quickly as possible to the boiling point, and is briskly boiled.* Portions of it, taken out at intervals upon bibulous paper, must be tested for nitrite with a solution of starch and potassium iodide. When the nitrite appears to be vanishing, the remaining half of the nitrite solution must be added by degrees, so as always to keep nitrite in solution; and it must remain distinctly acid with the original tartaric acid added. In about an hour the solution, which had become at first coffee-coloured, has acquired a fine clear red; but it must be boiled for some time longer. The reasons for the precautions in the manner of adding the nitrite, and preventing any large excess either of it or of acid, are the following:—Red prusside of potassium heated with sodic nitrite, becomes yellow prusside of sodium and potassium, which would remain unconverted. Again, if the tartaric acid has decomposed all the nitrite, and remains in the boiling solution, it decomposes the ferridcyanide, and forms Prussian blue. But if the above process be followed out, after one or two hours' boiling, the whole of the ferridcyanide is converted into nitroprusside. The progress is readily ascertained by placing from time to time a drop of the solution on bibulous paper, and touching it with a solution of the ferrous sulphate. The last traces of ferridcyanide are, however, the most difficult to obliterate. The solution is now evaporated and crystallized. Two abundant crops of nearly pure sodic nitroprusside may thus be obtained. The third crop is generally mixed with potassic chloride, and sodic and potassic tartrate, and has to be picked out from them.

---

* I prefer for this purpose sodic nitrite, made by fusing lead with sodic nitrate, lixiviating with water, and then adding H_2SO_4 cautiously, till the lead is precipitated.

Unless the precautions which have been described have been strictly attended to, a small quantity of sodic ferrocyanide will be found in the mother liquor.

---

* If the solution, on mixture, instead of being boiled, as recommended, be kept cool, a large quantity of nitroprusside is still formed, and a considerable amount of oxamide is deposited.

By the process now described sodic nitroprusside can be made in any quantity, and without the loss of any of the Cyanogen products. The reaction involved in the above process is extremely simple. The first portion of tartaric acid removes an atom of potassium, and substitutes it by hydrogen. The second portion of acid acts on the sodic nitrite, liberating nitrous acid:—

$$2FeCy_6K_2H + 2NO_2H = 2H_2O + 2FeCy_5NOK_2 + Cy_2.$$

The sodic chloride and tartrate exchange their sodium for the potassium of the nitroprusside, partly on addition, and more largely on crystallization.

3. Note on the Reality of the Roots of the Symbolical Cubic which expresses the Properties of a Self-conjugate Linear and Vector Function. By Professor Tait.

Hamilton has shown that if

$$\phi\rho = \Sigma\alpha S\beta\rho + A\rho,$$

where α and β are given vectors, and A a given scalar, we have

$$(\phi^3 - m_2\phi^2 + m_1\phi - m)\rho = 0,$$

where m, m_1, m_2 are scalars depending only on ϕ.

When the function ϕ *is its own conjugate*, *i.e.*, when

$$S\rho\phi\sigma = S\sigma\phi\rho,$$

ρ and σ being any vectors whatever, the vectors for which

$$(\phi - g)\rho = 0, \text{ or } \phi\rho \parallel \rho, \text{ or } V\rho\phi\rho = 0,$$

form in general a real and definite rectangular system. This, of course, may in particular cases degrade into one definite vector, and *any* pair of others perpendicular to it; and cases may occur in which the equation is satisfied for *every* vector.

Suppose the roots of $m_g = m + m_1 g + m_2 g^2 + g^3 = 0$ to be real and different, then

$$\left.\begin{aligned} \phi\rho_1 &= g_1\rho_1 \\ \phi\rho_2 &= g_2\rho_2 \\ \phi\rho_3 &= g_3\rho_3 \end{aligned}\right\} \text{ where } \rho_1, \rho_2, \rho_3 \text{ are definite vectors.}$$

Hence $$g_1 g_2 S\rho_1\rho_2 = S\varphi\rho_1\varphi\rho_2$$
$$= S\rho_1\varphi^2\rho_2, \text{ or } = S\rho_2\varphi^2\rho_1,$$

because φ is its own conjugate.

But $$\varphi^2\rho_2 = g_2^2\rho_2,$$
$$\varphi^2\rho_1 = g_1^2\rho_1,$$
and therefore
$$g_1 g_2 S\rho_1\rho_2 = g_2^2 S\rho_1\rho_2 = g_1^2 S\rho_1\rho_2;$$
which, as g_1 and g_2 are by hypothesis different, requires
$$S\rho_1\rho_2 = 0.$$
Similarly $$S\rho_2\rho_3 = 0, \qquad S\rho_3\rho_1 = 0.$$

If two roots be equal, as g_2, g_3, we still have, by the above proof, $S\rho_1\rho_2 = 0$, and $S\rho_1\rho_3 = 0$. But there is nothing farther to determine ρ_2 and ρ_3, which are therefore *any* vectors perpendicular to ρ_1.

If all three roots be equal, *every* real vector satisfies the equation $(\varphi - g)\rho = 0$.

Next, as to the *reality* of the three roots when the function is self-conjugate.

Suppose $g_2 + h_2\sqrt{-1}$ to be a root, and let $\rho_2 + \sigma_2\sqrt{-1}$ be the corresponding value of ρ, where g_2 and h_2 are real numbers, ρ_2 and σ_2 real vectors, and $\sqrt{-1}$ the old imaginary of algebra.

Then $$\varphi(\rho_2 + \sigma_2\sqrt{-1}) = (g_2 + h_2\sqrt{-1})(\rho_2 + \sigma_2\sqrt{-1}),$$

and this divides itself, as in algebra, into the two equations
$$\varphi\rho_2 = g_2\rho_2 - h_2\sigma_2,$$
$$\varphi\sigma_2 = h_2\rho_2 + g_2\sigma_2.$$

Operating on these by $S\sigma_2$, $S\rho_2$ respectively, and subtracting the results, remembering our condition as to the nature of φ
$$S\sigma_2\varphi\rho_2 = S\rho_2\varphi\sigma_2,$$
we have $$h_2(\sigma_2^2 + \rho_2^2) = 0.$$

But, as σ_2 and ρ_2 are both real vectors, the sum of their squares cannot vanish. Hence h_2 vanishes, and with it the impossible part of the root.

4. On Vortex Atoms. By Professor Sir William Thomson.

After noticing Helmholtz's admirable discovery of the law of vortex motion in a perfect liquid, that is, in a fluid perfectly destitute of viscosity (or fluid friction), the author said that this discovery inevitably suggests the idea that Helmholtz's rings are the only true atoms. For the only pretext seeming to justify the monstrous assumption of infinitely strong and infinitely rigid pieces of matter, the existence of which is asserted as a probable hypothesis by some of the greatest modern chemists in their rashly-worded introductory statements, is that urged by Lucretius and adopted by Newton; that it seems necessary to account for the unalterable distinguishing qualities of different kinds of matter. But Helmholtz has proved an absolutely unalterable quality in the motion of any portion of a perfect liquid, in which the peculiar motion which he calls "wirbel-bewegung" has been once created. Thus, any portion of a perfect liquid which has "wirbel-bewegung" has one recommendation of Lucretius' atoms—infinitely perennial specific quality. To generate or to destroy "wirbel-bewegung" in a perfect fluid can only be an act of creative power. Lucretius' atom does not explain any of the properties of matter without attributing them to the atom itself. Thus the "clash of atoms," as it has been well called, has been invoked by his modern followers to account for the elasticity of gases. Every other property of matter has similarly required an assumption of specific forces pertaining to the atom. It is as easy (and as improbable—not more so) to assume whatever specific forces may be required in any portion of matter which possesses the "wirbel-bewegung," as in a solid indivisible piece of matter, and hence the Lucretius atom has no *prima facie* advantage over the Helmholtz atom. A magnificent display of smoke-rings, which he recently had the pleasure of witnessing in Professor Tait's lecture-room, diminished by one the number of assumptions required to explain the properties of matter, on the hypothesis that all bodies are composed of vortex atoms in a perfect homogeneous liquid. Two smoke-rings were frequently seen to bound obliquely from one another, shaking violently from the effects of the shock. The result was very similar to that observable in two large india-rubber rings striking one another in the air. The elasticity of each smoke-ring seemed no further from perfection than might be expected in a solid india-rubber ring of the same shape from what we know of the viscosity of india-rubber. Of course this kinetic elasticity of form is perfect elasticity for vortex rings in a perfect liquid. It is at least as good a beginning as the "clash of atoms" to account for the elasticity of gases. Probably the beautiful investigations of D. Bernouilli, Herapath, Joule, Krönig, Clausius, and Maxwell, on the various thermodynamic properties of gases, may have all the positive assumptions they have been obliged to make as to mutual forces between two atoms and kinetic energy acquired by individual atoms or molecules, satisfied by vortex rings, without requiring any other property in the matter whose motion composes them than inertia and incompressible occupation of space. A full mathematical investigation of the mutual action between two vortex rings of any given magnitudes and velocities, passing one another in any two lines, so directed that they never come nearer one another than a large multiple of the diameter of either, is a perfectly solvable mathematical problem; and the novelty of the circumstances contemplated presents difficulties of an exciting character. Its solution will become the foundation of the proposed new kinetic theory of gases. The possibility of founding a theory of elastic solids and liquids on the dynamics of more closely-packed vortex atoms may be reasonably anticipated. It may be remarked, in connection with this anticipation, that the mere title of Rankine's paper on "Molecular Vortices," communicated to the Royal Society of Edinburgh in 1849 and 1850, was a most suggestive step in physical theory.

Diagrams and wire models were shown to the Society, to illustrate knotted or knitted vortex atoms, the endless variety of which is infinitely more than sufficient to explain the varieties and allotropies of known simple bodies and their mutual affinities. It is to be remarked that two ring atoms linked together, or one knotted in any manner with its ends meeting, constitute a system which, however it may be altered in shape, can never deviate from its own peculiarity of multiple continuity, it being impossible for the matter in any line of vortex motion to go through the line of any other matter in such motion or any other part of its own line. In fact, a closed line of vortex core is literally indivisible by any action resulting from vortex motion.

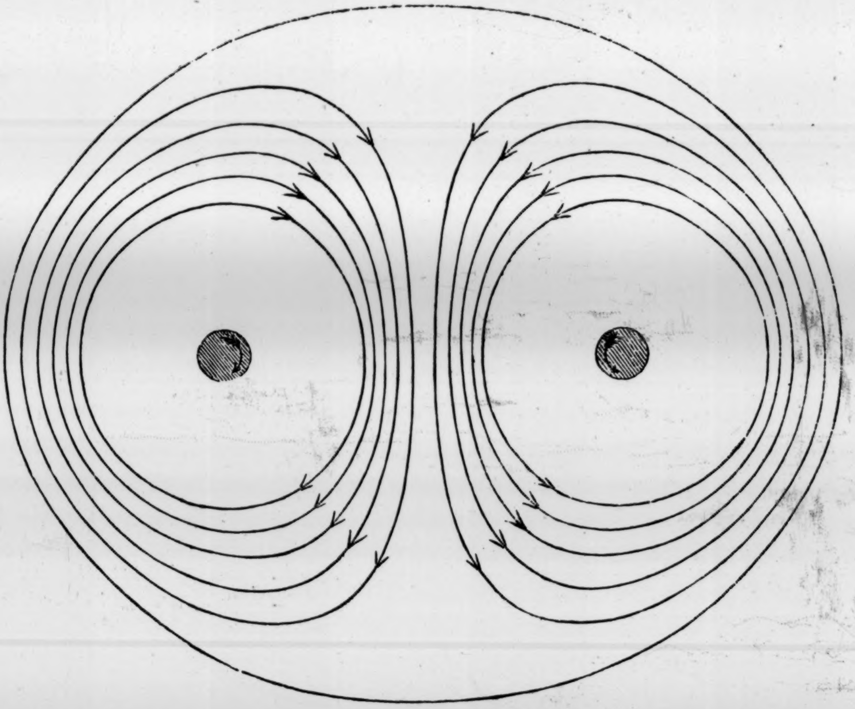
The author called attention to a very important property of the vortex atom, with reference to the now celebrated spectrum analysis practically established by the discoveries and labours of Kirchof and Bunsen. The dynamical theory of this subject, which Professor Stokes had taught to the author of the present paper before September 1852, and which he has taught in his lectures in the University of Glasgow from that time forward, required that the ultimate constitution of simple bodies should have one or more fundamental periods of vibration, as has a stringed instrument of one or more strings, or an elastic solid consisting of one or more tuning forks rigidly connected. To assume such a property in the Lucretius atom, is at once to give it that very flexibility and elasticity, for the explanation of which, as exhibited in aggregate bodies, the atomic constitution was originally assumed. If, then, the hypothesis of atoms and vacuum imagined by Lucretius and his followers to be necessary to account for the flexibility and compressibility of tangible solids and fluids, were really necessary, it would be necessary that the molecule of sodium, for instance, should be not an atom, but a group of atoms with void space between them. Such a molecule could not be strong and durable, and thus it loses the one recommendation, which has given it the degree of acceptance it has had among philosophers; but, as the experiments shown to the Society illustrate, the vortex atom has perfectly definite fundamental modes of vibration, depending solely on that motion, the existence of which constitutes it. The discovery of these fundamental modes forms an intensely interesting problem of pure mathematics. Even for a simple Helmholtz ring, the analytical difficulties which it presents are of a very formidable character, but certainly far from insuperable in the present state of mathematical science. The author of the present communication had not attempted, hitherto, to work it out except for an infinitely long, straight, cylindrical vortex. For this case he is working out solutions corresponding to every possible description of infinitesimal vibration, and intended to include them in a mathematical paper, which he hoped soon to be able to communicate to the Royal Society. One very simple result which he could now state is the following. Let such a vortex be given with its section differing from exact circular figure by an infinitesmal harmonic deviation of order i. This *form* will travel as waves round the axis of the cylinder in the same direction as the vortex rotation, with an angular velocity equal to $\frac{i-1}{i}$ of the angular velocity of this rotation. Hence, as the number of crests in a whole circumference is equal to i, for a harmonic deviation of order i, there are $i-1$ periods of vibration, in the period of revolution of the vortex. For the case $i=1$ there is no vibration, and the solution expresses merely an infinitesimally displaced vortex with its circular form unchanged. The case $i=2$ corresponds to elliptic deformation of the circular section; and for it the period of vibration is simply, therefore, the period of revolution. These results are, of course, applicable to the Helmholtz ring, when the diameter of the approximately circular section is small in comparison with the diameter of the ring, as it is in the smoke-rings exhibited to the Society. The lowest fundamental modes of the two kinds of transverse vibrations of a ring, such as the vibrations that were seen in the experiments, must be much graver than the elliptic vibration of section. It is probable that the vibrations which constitute the incandescence of sodium vapour are analogous to those which the smoke-rings had exhibited; and it is therefore probable that the period of the vortex rotations of the atoms of sodium vapour are much less than $\frac{1}{525}$ of the millionth of the millionth of a second, this being approximately the period of vibration of the yellow sodium light. Further, inasmuch as this light consists of two sets of vibrations co-existent in slightly different periods, equal approximately to the time just stated, and of as nearly as can be perceived equal intensities; the sodium atom must have two fundamental modes of vibration, having those for their respective periods, and being about equally excitable by such forces as the atom experiences in the incandescent vapour. This last condition renders it probable that the two fundamental modes concerned are approximately similar (and not merely different orders of different series chancing to concur very nearly in their periods of vibration). In an approximately circular and uniform disc of elastic solid the fundamental modes of transverse vibration, with nodal division into quadrants, fulfils both the conditions. In an approximately circular and uniform ring of elastic solid these conditions are fulfilled for the flexural vibrations in its plane, and also in its transverse vibrations perpendicular to its own plane. But the circular vortex ring, if created with one part somewhat thicker than another, would not remain so, but would experience longitudinal vibrations round its own circumference, and could not possibly have two fundamental modes of vibration similar in character and approximately equal in period. The same assertion may, it is probable,* be practically extended to any atom consisting of a single vortex ring, however involved, as illustrated by those of the models shown to the Society, which consisted of only a single wire, knotted in various ways. It seems, therefore, probable that the sodium atom may not consist of a single vortex line; but it may very probably consist of two approximately equal vortex rings passing through one another, like two links of a chain. It is, however, quite certain that a vapour consisting of such atoms, with proper volumes and angular velocities in the two rings of each atom, would act precisely as incandescent sodium vapour acts; that is to say, would fulfil the "spectrum test" for sodium.

The possible effect of change of temperature on the fundamental modes cannot be pronounced upon without mathematical investigation not hitherto executed; and therefore we cannot say that the dynamical explanation now suggested is mathematically demonstrated so far as to include the very approximate identity of the periods of the vibrating particles of the incandescent vapour with those of their corresponding fundamental modes, at the lower temperature, at which the vapour exhibits its remarkable absorbing power for the sodium light.

A very remarkable discovery made by Helmholtz regarding the simple vortex ring is, that it always moves, relatively to the distant parts of the fluid, in a direction perpendicular to its plane towards the side towards which the rotatory motion carries the inner parts of the ring. The determination of the velocity of this motion, even approximately for rings of which the sectional radius is small in comparison with the radius of the circular axis, has presented mathematical difficulties which have not yet been overcome.

---

* [*Note, April* 25, 1867.—The author has recently seen reason for believing that the sodium characteristic might be realised by a certain configuration of a single line of vortex core to be described in the mathematical paper which he intends to communicate to the Society.]



In the smoke-rings which have been actually observed, it seems to be always something smaller than the velocity of the fluid along the straight axis through the centre of the ring; for the observer standing beside the line of motion of the ring, sees, as its plane passes through the position of his eye, a convex* outline of an atmosphere of smoke in front of the ring. This convex outline indicates the bounding surface between the quantity of smoke which is carried forward with the ring in its motion, and the surrounding air which yields to let it pass. It is not so easy to distinguish the corresponding convex outline behind the ring, because a confused trail of smoke is generally left in the rear. In a perfect fluid the bounding surface of the portion carried forward would necessarily be quite symmetrical on the anterior and posterior sides of the middle plane of the ring. The motion of the surrounding fluid must be precisely the same as it would be if the space within this surface were occupied by a smooth solid; but in reality the air within it is in a state of rapid motion, circulating round the circular axis of the ring with increasing velocity on the circuits nearer and nearer to the ring itself. The circumstances of the actual motion may be imagined thus:—Let a solid column of india-rubber, of circular section, with a diameter small in proportion to its length, be bent into a circle, and its two ends properly spliced together, so that it may keep the circular shape when left to itself; let the aperture of the ring be closed by an infinitely thin film; let an impulsive pressure be applied all over this film, of intensity so distributed as to produce the definite motion of the fluid, specified as follows, and instantly thereafter let the film be all liquefied. This motion is, in accordance with one of Helmholtz's laws, to be along those curves which would be the lines of force, if, in place of the india-rubber circle, were substituted a ring electro-magnet,* and the velocities at different points are to be in proportion to the intensities of the magnetic forces in the corresponding points of the magnetic field. The motion, as has been long known, will fulfil this definition, and will continue fulfilling it, if the initiating velocities at every point of the film perpendicular to its own

---

* The diagram represents precisely the convex outline referred to, and the lines of motion of the interior fluid carried along by the vortex, for the case of a double vortex consisting of two infinitely long, parallel straight vortices of equal rotations in opposite directions. The curves have been drawn by

---

Mr D. M'Farlane, from calculations which he has performed by means of the equation of the system of curves, which is

$$\frac{y^2}{a^2}=\frac{2x}{a}\cdot\frac{\mathrm{N}+1}{\mathrm{N}-1}-\left(1+\frac{x^2}{a^2}\right), \text{ where } \log_\epsilon \mathrm{N}=\frac{x+b}{a},$$

The proof will be given in the mathematical paper which the author intends to communicate in a short time to the Royal Society of Edinburgh.

* That is to say, a circular conductor with a current of electricity maintained circulating through it.

plane be in proportion to the intensities of the magnetic force in the corresponding points of the magnetic field. Let, now, the ring be moved perpendicular to its own plane in the direction *with* the motion of the fluid, through the middle of the ring, with a velocity very small in comparison with that of the fluid at the centre of the ring. A large approximately globular portion of the fluid will be carried forward with the ring. Let the velocity of the ring be increased; the volume of fluid carried forward will be diminished in every diameter, but most in the axial or fore-and-aft diameter, and its shape will thus become sensibly oblate. By increasing the velocity of the ring forward more and more this oblateness will increase, until, instead of being wholly convex it will be concave, before and behind, round the two ends of the axis. If the forward velocity of the ring be increased until it is just equal to the velocity of the fluid, through the centre of the ring, the axial section of the outline of the portion of fluid carried forward will become a lemniscate. If the ring be carried still faster forward, the portion of it carried with the india-rubber ring will be itself annular; and, relatively to the ring, the motion of the fluid will be backwards through the centre. In all cases, the figure of the portion of fluid carried forward, and the lines of motion, will be symmetrical, both relatively to the axis and relatively to the two sides of the equatorial plane. Any one of the states of motion thus described might of course be produced either in the order described, or by first giving a velocity to the ring, and then setting the fluid in motion by aid of an instantaneous film, or by applying the two initiative actions simultaneously. The whole amount of the impulse required, or, as we may call it, the effective momentum of the motion, or simply the momentum of the motion, is the sum of the integral values of the impulses on the ring and on the film required to produce one or other of the two components of the whole motion. Now it is obvious that, as the diameter of the ring is very small in comparison with the diameter of the circular axis, the impulse on the ring must be very small in comparison with the impulse on the film, unless the velocity given to the ring is much greater than that given to the central parts of the film. Hence, unless the velocity given to the ring is so very great as to reduce the volume of the fluid carried forward with it to something not incomparably greater than the volume of the solid ring itself, the momenta of the several configurations of motions we have been considering will exceed by but insensible quantities the momentum when the ring is fixed. The value of this momentum is easily found by a proper application of Green's formulæ. Thus the actual momentum of the portion of fluid carried forward (being the same as that of a solid of the same density moving with the same velocity), together with an equivalent for the inertia of the fluid yielding to let it pass, is approximately the same in all these cases, and is equal to a Green's integral expressing the whole initial impulse on the film. The equality of the effective momentum for different velocities of the ring is easily verified without analysis for velocities not so great as to cause sensible deviations from spherical figure in the portion of fluid carried forward. Thus, in every case, the length of the axis of the portion of the fluid carried forward is determined by finding the point in the axis of the ring at which the velocity is equal to the velocity of the ring. At great distances from the plane of the ring this velocity varies, as does the magnetic force of an infinitesimal magnet on a point in its axis, inversely as the cube of the distance from the centre. Hence the cube of the radius of the approximately globular portion carried forward is in simple proportion to the velocity of the ring, and therefore its momentum is constant for different velocities of the ring. To this must be added, as was proved by Poisson, a quantity equal to half its own amount, as an equivalent for the inertia of the external fluid; and the sum is the whole effective momentum of the motion. Hence we see not only that the whole effective momentum is independent of the velocity of the ring, but that its amount is the same as the magnetic moment in the corresponding ring electro-magnet. The same result is, of course, obtained by the Green's integral referred to above.

The synthetical method just explained is not confined to the case of a single circular ring specially referred to, but is equally applicable to a number of rings of any form, detached from one another, or linked through one another, in any way, or to a single line knotted to any degree and quality of "multiple continuity," and joined continuously, so as to have no end. In every possible such case, the motion of the fluid at every point, whether of the vortex core or of the fluid filling all space round it, is perfectly determined by Helmholtz's formulæ, when the shape of the core is given. And the synthetic investigation now explained proves that the effective momentum of the whole fluid motion agrees, in magnitude and direction, with the magnetic moment of the corresponding electro-magnet. Hence, still considering, for simplicity, only an infinitely thin line of core, let this line be projected on each of three planes at right angles to one another. The areas of the plane circuits thus obtained (to be reckoned, according to De Morgan's rule, when automic, as they will generally be), are the components of momentum perpendicular to these three planes. The verification of this result will be a good exercise on "multiple continuity." The author is not yet sufficiently acquainted with Riemann's remarkable researches on this branch of analytical geometry, to know whether or not all the kinds of "multiple continuity" now suggested are included in his classification and nomenclature.

That part of the synthetical investigation in which a thin solid wire ring is supposed to be moving in any direction through a fluid with the free vortex motion previously excited in it, requires the diameter of the wire at every point to be infinitely small in comparison with the radius of curvature of its axis and with the distance of the nearest of any other part of the circuit from that point of the wire. But when the effective moment of the whole fluid motion has been found for a vortex with infinitely thin core, we may suppose any number of such vortices, however, near one another to be excited simultaneously: and the whole effective momentum, in magnitude and direction, will be the resultant of the momenta of the different component vortices each estimated separately. Hence we have the remarkable proposition that the effective momentum of any possible motion in an infinite incompressible fluid agrees in direction and magnitude with the magnetic moment of the corresponding electro-magnet in Helmholtz's theory. The author hopes to give the mathematical formulæ expressing and proving this statement in the more detailed paper, which he hopes soon to be able to lay before the Royal Society.

The question early occurs to any one either observing the phenomena of smoke-rings or investigating the theory—What conditions determine the size of the ring in any case? Helmholtz's investigation proves that the angular vortex velocity of the core varies directly as its length, or inversely as its sectional area. Hence the strength of the electric current in the electro-magnet, corresponding to an infinitely thin vortex core, remains constant, however much its length may be altered in the course of the transformations which it experiences by the motion of the fluid. Hence it is obvious that the larger the diameter of the ring, for the same volume and strength of vortex motions in an ordinary Helmholtz ring, the greater is the whole kinetic energy of the fluid, and the greater is the momentum; and we therefore see that the dimensions of a Helmholtz ring are determinate when the volume and strength of the vortex motion are given, and besides, either the kinetic energy or the momentum of the whole fluid motion due to it. Hence if, after any number of collisions or influences, a Helmholtz ring escapes to a great distance from others and is then free, or nearly free, from vibrations, its diameter will have been increased or diminished according as it has taken energy from, or given energy to, the others. A full theory of the swelling of vortex atoms by elevation of temperature is to be worked out from this principle.

Professor Tait's plan of exhibiting smoke rings is as follows:— A large rectangular box, open at one side, has a circular hole of six or eight inches diameter cut in the opposite side. A common rough packing-box of two feet cube or thereabout will answer the purpose very well. The open side of the box is closed by a stout towel or piece of cloth, or by a sheet of India-rubber stretched across it. A blow on this flexible side causes a circular vortex ring to shoot out from the hole on the other side. The vortex rings thus generated are visible, if the box is filled with smoke. One of the most convenient ways of doing this is to use two retorts with their necks thrust into holes made for the purpose in one of the sides of the box. A small quantity of muriatic acid is put into one of these retorts, and of strong liquid ammonia into the other. By a spirit-lamp applied from time to time to one or other of these retorts, a thick cloud of sal-ammoniac is readily maintained in the inside of the box. A curious and interesting experiment may be made with two boxes thus arranged, and placed either side by side, close to one another, or facing one another so as to project smoke-rings meeting from opposite directions; or in various relative positions, so as to give smoke-rings proceeding in paths inclined to one another at any angle, and passing one another at various distances. An interesting variation of the experiment may be made by using clear air without smoke in one of the boxes. The invisible vortex rings projected from it render their existence startlingly sensible, when they come near any of the smoke rings proceeding from the other box.

The following Gentleman was admitted a Fellow of the Society:—

JOHN M. M'CANDLISH, Esq., W.S.,

The following Donations to the Society were announced:—

Proceedings of the Royal Society of London. Vol. XV. No. 89. 8vo.—*From the Society.*

Proceedings of the Natural History Society of Dublin. Vol. IV. Part 3. 8vo.—*From the Society.*

Quarterly Journal of the Geological Society, London. Vol. XXIII. Part 1. 8vo.—*From the Society.*

Journal of the Chemical Society, London. Vol. V. No. 1. 8vo.—*From the Society.*

Ninth Detailed Annual Report of the Registrar-General of Births, Deaths, and Marriages in Scotland. Edinburgh, 1867. 8vo. —*From the Registrar-General.*

An Elementary Treatise on Quartz and Opal. By George Wm. Traill, F.G.S.E. Edinburgh, 1867. 8vo.—*From the Author.*

Bulletin de la Société de Géographie. Paris, Janvier, 1867. 8vo. —*From the Society.*

Die Urzeit der Erde, gedicht von Franz v. Kobell. München, 1856. 8vo.—*From the Author.*

Akademische Denkreden von Dr Carl Fr. Ph. v. Martius. Leipzig, 1866. 8vo.—*From the Author.*

Bulletin de la Société Impériale des Naturalistes de Moscou. No. 3, 1865; No. 2, 1866. 8vo.—*From the Society.*

Berichte über die Verhandlungen der Königlich Sachsischen Gesellschaft der Wissenschaften zu Leipzig. Mathematisch—Physische Classe No. 1–3. 1866. 8vo.—*From the Society.*

Abhandlungen der Philosophisch - Philologischen Classe der Königlich Bayerischen Akademie der Wissenschaften. Band XXXIX. B. XLII. Historischen Classe. B. XXXVIII. München, 1866. 4to.—*From the Academy.*

Abhandlungen herausgegeben von der Senckenbergischen Naturforschenden Gesellschaft. Band VI. No. 1, 2. Frankfurt, 1866. 4to.—*From the Society.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. Band XVI. No. 2, 3. Wien, 1866. 8vo.—*From the Society.*

Elektrische Untersuchungen, Siebente Abhandlung. Uber die Thermoelektrischen Eigenschaften des Bergkrystalles. Von W. G. Hankel. Leipzig, 1866. 8vo.—*From the Natural History Society, Leipzig.*

Bestimmung des Längenunterschiedes zwischen den Sternwarten zu Gotha und Leipzig. Von P. A. Hansen. Leipzig, 1866. 8vo.—*From the Natural History Society, Leipzig.*

Monday, 4*th March* 1867.

SIR DAVID BREWSTER, President, in the Chair.

The following Communications were read :—

1. On the Arctic Shell Clay of Elie and Errol, viewed in connection with our other Glacial and more Recent Deposits. By the Rev. Thomas Brown, F.R.S.E.

Referring to the papers formerly read before the Society in 1863 and 1864, the author first noticed the Section at Errol, its stratigraphical position and fossils, more especially the skeleton of a seal which had been found in the clay. He then described more in detail the different deposits as they occur in the neighbourhood of Elie. Since the shore Section was described in 1863 two new Sections had been examined, and the position of the different beds more fully ascertained. One was in the railway cutting extending from Elie Bridge to the Railway Station, in which, when first laid open, the series of deposits was remarkably well displayed. Beginning a little to the east of the station, the following beds were seen in the descending order :—

1. Blown sand with intercalated beds of shell-bearing peat, one of which was six feet in thickness. This upper portion of the series is largely developed.

2. A peculiar bed of peat destitute of shells, and apparently a continuation of that at the shore,—the submerged forest.

3. A portion of the high-level stratified gravels and sands of the district.

At this point there is a break in the series. The portion above is unconformable to that beneath.

4. The arctic shell clay—a continuation of the same deposit seen on the shore about one-third of a mile distant.

5. The boulder-clay in two stages, with large boulders enclosed.

6. The basement bed of the boulder-clay full of shivers, and resting immediately on the rock.

These different deposits are seen in regular succession from east to west.

The other Section lies to the westward of Kincraig, and runs nearly at right angles to the former, passing from the shore inland up the course of the Cockle Mill Burn. It shows the following beds:—

1. Blown sand rising into dunes close to the shore.

2. The so called raised beach consisting of sand, shingle, and shells in layers, the shells being the common species of the shore, and very much in the same state as those now on the beach. This deposit is powerfully displayed, rising at some points to twenty feet above high-water mark.

3. Further inland, and apparently underlying No. 2, is a series of sands and clays in contorted layers. Marine shells occur at various points. One of the layers of clay was pointed out containing numerous specimens of *Scrobicularia piperata* in their natural position, with the siphonal end uppermost. As this bed is from twelve to fourteen feet above high-water mark, attention was called to the evidence thus furnished for a rise in the bed of the Firth, and its remarkable coincidence with the evidence furnished by the same deposits at Stirling and Portobello.

4. The submerged forest of Largo Bay as it is found near the mouth of the stream, between tide-marks.

The additional species of shells were described as determined by Dr O. Tozell, and the still more complete evidence thus furnished of extreme arctic cold.

2. On the Motions and Colours upon Films of Alcohol, Volatile Oils, and other Fluids. By Sir David Brewster, K.H., F.R.S., &c.

In a paper "On the Phenomena of thin Plates exposed to Polarised Light," published in the Philosophical Transactions for 1841, the author observed certain motions and colours upon some of the volatile and fixed oils, the cause of which he did not attempt to discover. Their apparent similarity to the molecular movements and colours, described in a preceding paper, induced him to resume the subject.

When a drop of alcohol is placed upon an aperture the fifth of an inch in diameter or less, a concave lens will be formed upon it. As the alcohol evaporates, a very small plane film will appear in the centre, and will gradually increase till it fills the aperture. If held in a vertical or even inclined position, and examined by transmitted light, a current of fluid, without colour, will be seen issuing from the margin of the film, moving quickly to different parts of its circumference, sometimes dividing itself into two currents dancing opposite one another, and then extending into secondary currents in constant motion. Similar currents are produced upon various alcoholic solutions and a large number (seventy to eighty) of volatile oils, &c.

If we now examine the film by reflected light, the principle and secondary currents will be seen as before, but accompanied with systems of coloured rings of great beauty, shifting their place on the film, sometimes in rotation, expanding and contracting quickly, and changing their form and colour.

In small films there is often only one system of rings contracting and expanding with a constant variation of the central tint. In general, however, there are two, three, or several systems—each system being produced by a secondary current giving motion to the colouring matter on the surface of the film. In some cases the motions and colour disappear, the film becomes colourless, and tints issue from its margin as on the soap-bubble; but, in general, the film bursts before this takes place. The colourless currents and the colours into which they expand are supposed by the author to have the same origin as those upon the soap-bubble. The paper is illustrated with drawings of the currents and of the systems of rings.

3. Note on the Action of Nitric Oxide, Nitrous Acid, and Nitrites on Hæmoglobin. By Arthur Gamgee, M.D., F.R.S.E., F.C.S.

When engaged, during the course of last summer, in the examination of the action of various medicinal and poisonous agents on blood, I observed the remarkable change in the colour of the blood of animals poisoned with nitrite of amyl. In every case in which I induced death by this agent the blood presented a dirty chocolate coloration, instead of the characteristic colour of normal blood. When examined by means of the spectroscope, this blood was found to present optical characters very different from those of ordinary blood, for the two well-marked absorption bands of 0 – hæmoglobin, or (as the readers of Professor Stokes' paper will know them better as) of scarlet cruorine, were found to be extremely faint, and only visible when comparatively thick layers of fluid were examined; whilst an additional and very faint absorption band in the red, occupying the same position as that of acid hæmatine, was seen. I at first thought that the acids, generated by the oxidation of the nitrite, had acted upon the blood-colouring matter in the same manner as weak acids usually do, effecting a partial conversion into hæmatin, so that whilst the bands of hæmoglobin were yet visible, the one characteristic of hæmatin had been super-added. The total incorrectness of this view was proved on a more careful examination being made. On adding a few drops of ammonia to the blood-solution in which nitrite of amyl had effected the peculiar change alluded to, its colour again became red, and whilst the band in the red instantly and totally disappeared, the two absorption bands situated between D and E became much more distinct. Moreover, a third very faint absorption band was found occupying the junction of the orange and yellow, and just below Frauenhofer's line D. On now treating the blood solutions with such deoxidising agents as protosalts of iron and tin and sulphide of ammonium, a spectrum, differing in no respect from that of reduced hæmoglobin, was obtained, and the solution, when agitated with air, presented the most beautiful spectrum of oxy-hæmoglobin, *i.e.*, the two bands α and β reassumed all the distinctness and beauty which they presented in the unaltered blood solution.

Nitrite of ethyl was found to effect exactly the same alteration as nitrite of amyl, whilst, as might be expected, vinic and amylic alcohols, when added in small quantities to blood, were without any effect. When solutions of nitrite of sodium or of potassium were added to blood, instantly the same change was noticed as was produced by amylic and vinic nitrites. On very faintly acidulating blood with acetic acid, and subsequently adding a small quantity of a solution of nitrite of sodium, the same change occurred.

In this case the change must have been due to the nascent nitrous acid, or to the nitric oxide secondarily resulting from it. In order to endeavour to determine whether the body produced under the influence of nitrites was really due to the action of nitrous acid, or whether, on the contrary, it was formed through the agency of nitric oxide, I performed the following experiment. Perfectly pure nitric oxide was passed into blood, exactly the same arrangements being employed as were used by Hadow in his experiments on the constitution of nitro-prussides; instead, however, of generating the nitric oxide by the action of nitric oxide on copper, the gas was obtained by boiling a solution of ferric sulphate, which had been saturated with $N\Theta$, in a stream of carbonic acid. After the action of nitric oxide had gone on for some seconds, the line in the red made its appearance, and the two hæmoglobin bands became very indistinct, whilst the colour of the blood became brown; the same changes were thus induced as were found to occur when nitrites act upon blood. On the addition of ammonia the band in the red disappeared, and the spectrum was marked by the band in the orange, to which allusion has already been made.

Although this observation appeared to point to nitric oxide as the agent in effecting the change, it was perfectly possible that, in reality, it was due to nitrous acid, for it appeared likely that this acid might be formed in the blood by the nitric oxide seizing that portion of the oxygen of the blood-colouring matter, which is capable of removal by reducing agents, or capable of expulsion by carbonic oxide. It would indeed appear from my experiments that nitrous acid is produced in the reaction, as when by means of a long funnel a mixture of potassic iodide, starch, and acetic acid is conducted to the bottom of a blood solution, and through which nitric oxide is passing, a blue colour is produced.

In order to separate, if possible, the substance formed under the influence of $N\Theta$ in a crystalline form, the blood of a dog was allowed to coagulate, and after complete separation of the serum the clot was squeezed in linen. The red fluid thus expressed was mixed with one-and-a-half times its volume of water, and then solution of nitrite of sodium added, until the characteristic spectrum was obtained. The fluid was then mixed with one-fourth of its volume of 86 per cent. alcohol, when it became filled with microscopic needles and prisms identical with those of O – hæmoglobin. They merely differed from the latter in having a dirty brown colour. They were collected on filter paper, washed with ice-cold water, pressed, and afterwards mixed with a considerable quantity of water. They did not, however, entirely redissolve, a small quantity of a white albuminoid substance remaining undissolved. The solution of the crystals presented the same spectrum as the blood from which they had been precipitated.

At the present stage of my researches it would be premature to express an opinion on the nature of the substance produced, when hæmoglobin is acted upon by nitrites and nitrous acid. That it holds a very close relation, indeed, to 0 – hæmoglobin, with which it appears to be isomorphous, is obvious, whilst it is most improbable that it has any analogy to the bodies formed when blood-colouring matter is treated with carbonic oxide, or when subjected to the prolonged action of nitric oxide, *in the presence of ammonia.* When CO acts upon blood, or, as Hermann has recently shown, when NΘ is made for a long time to pass through blood made alkaline with ammonia, there are formed compounds in which one volume of CO or one volume of NΘ have respectively replaced one volume of oxygen in the colouring matter—compounds which present exactly the same spectrum as ordinary blood, but which differ from it in being totally irreducible. That N_2O_3 should form a compound of this character seems improbable, and that NO should form two altogether distinct compounds with blood-colouring matter, is even more improbable. It is, however, much more likely that the action of nitrites and nitrous acid is mainly a reducing action, and that the body obtained by me is merely a less oxygenised form of blood-colouring matter.

4. Antiquities, Scenery, &c., of Cambodia, illustrated by a series of Photographs, shown by the Oxyhydrogen Light. By J. Thomson, Esq., F.R.G.S. Communicated by Professor Sir J. Y. Simpson, Bart.

The following Gentlemen were elected Fellows of the Society:—

JAMES DONALDSON, LL.D.
JAMES RICHARDSON, Esq.

The following Donations to the Library were announced:—

Transactions of the Linnean Society of London. Vol. XXV. Part 3. 4to.—*From the Society.*

List of the Linnean Society of London for 1866. 8vo.—*From the Society.*

Report of Proceedings of International Horticultural Exhibition and Botanical Congress, held in London from 22d to 31st May 1866. 8vo.—*From the Acting Committee.*

Madras Journal of Literature and Science for October 1866. 8vo. —*From the Society.*

Monday, 18th March 1867.

Sir DAVID BREWSTER, President, in the Chair.

The following Communications were read:—

1. On the Application of Relative, or Proportional, Equality to International Organisation. By Professor Lorimer.

It is often regarded almost as a matter of admission, on the part of the cultivators of social and political philosophy, that their subjects defy scientific treatment; and that, when they talk of tracing out laws of social wellbeing or progress, they use words which indicate, at most, a very faint analogy between the methods which they affect to follow, and those really employed in the physical sciences. The reproach to which they are exposed, on this ground, would never have arisen, or would not have been merited, had they habituated themselves and others to regard their subject, as a science, in the ordinary sense of an inquiry into nature, and not as a series of random observations, in which the contingent and the necessary, the permanent and the accidental, were hopelessly and inextricably mixed up. Political methodology, viewed as a branch of applied logic, has risen, in the hands of some of its recent cultivators, almost to the dignity of a separate science. By eliminating impossible schemes, and thus circumscribing the sphere of political effort, it has already given evidence of its practical value. Within the state, forms of government, after which the vulgar still aspire as the ideal forms of society, have been shown by its means to be permanently irreconcilable with order, and if with order, then with liberty, which is possible only through order, and so ultimately with civilisation itself.

But all that can be attempted on the present occasion, is to point out two principles, the realisation of which can be shown to be impossible, and which have, nevertheless, been sought to be realised in conjunction with every scheme of international organisation which has yet been propounded. These principles are :—

1. *Finality.*—In national politics this principle has been exhibited in those arbitrary, and, in some states, impassable lines between classes, which science has long ago condemned, and which practical men are everywhere engaged in obliterating. In schemes of international organisation, it has sought to manifest itself in the establishment of final and permanent international relations, or in the maintenance of what is technically called a *status quo*.

2. *Absolute equality of rights and obligations.*—In internal politics this principle is the basis of the form of government called Democracy. In international politics it has exhibited itself in the custom of assigning equal votes to all the members of the family of nations, not absolutely excluded from the European council board, however widely they might differ in real power and importance.

As regarded the first of these principles, the absurdity of attempting to stereotype the map of Europe will be readily admitted. With reference to the second, there is much difference of opinion, both as to the possibility and the justice of recognising, or declaring absolute political equality, whether within the state or in the wider commonwealth of nations. Now this diversity of opinion, great as it is, and terrible as have been, and may yet be its effects, is traceable to a defect in the popular mind, on which Aristotle, with his usual perspicacity, put his finger more than two thousand years ago. "The vulgar," he says, "do not distinguish," and in modern Europe, for nearly a century, they have lost sight of a distinction which Aristotle did them the farther favour to point out.

The distinction is that between *absolute and relative* or *proportional equality*.

The two are, in truth, neither more nor less than two different manifestations of the principle of justice. They differ not in themselves, but in the manner of their application, and in the subject matter with which they deal. Following, and giving definiteness, as usual, to Plato's conception of what, in its origin, was probably the teaching of Socrates, Aristotle gave to these two forms of applied justice the names of *diorthotic* and *dianemetic justice* (*δίκαιον δίορθωτικον* and *δίκαιον δίανεμητικον*), names which the schoolmen and jurists rendered by *justicia correctiva* or *commutativa*, and *justicia distributiva.* The object of diorthotic or corrective justice Aristotle explained to be, to give to each a perfectly fair, unbiassed, and, *in that sense*, *equal* opportunity of vindicating whatever might be due to him, whether the amount was greater or smaller than that which was due to his neighbour. This was what we call equality before the law; and justice demanded that equality, in this sense, should be *absolute.* There was to be no distinction whatever of rich or poor, wise or foolish, male or female, old or young. The object of dianemetic justice, on the other hand, was to ascertain *how much* was due to each, and to *rank* them accordingly. Here was still equality, *perfect* equality, but equality which was no longer *absolute*, but *relative.* It was *proportioned* to the facts which the claimants respectively established with reference to the matter in dispute. So far all is clear. There can be no doubt that this was what Aristotle meant, and as little doubt that he was right. As to the application of the doctrine there is great confusion in the text, and even Sir Alexander Grant has not made much of it. What it seems to indicate is, that diorthotic justice, or absolute equality, is applicable to private—and dianemetic justice, or relative equality, to public questions, *and both exclusively.* But this could scarcely have been Aristotle's meaning. Both principles come into play in every department of jurisprudence, and are called into action in the decision of every case, from the most insignificant question of private right to the most momentous questions of national or international policy. And the method of their action is this: The first principle—absolute equality—governs the conduct of the suit, or of the investigation, whatever form it may take, whether it be conducted for judicial, legislative, or social purposes. The second, relative equality, governs the decision of the cause, whether that decision be pronounced in a small-debt court, in a national legislature, in a congress of nations, or in a club of gossips. As an illustration of the mutual action of these principles in private law, take the familiar case of the distribution of a bankrupt estate. One man has invested L.5 in the concern, and another L.50. *As suitors*, the law puts them on a footing of *absolute* equality. No preference is given to Jew or to Gentile, to noble or to simple, to white skin or to black skin. So far they are dealt with diorthotically. But then the dianemetic, or distributive principle, comes into play;—and suppose the estate to yield a shilling in the pound, one man gets five shillings, and the other gets fifty. The *distribution* has reference to the *objects* of the suit, not to the suitors, and is wholly dianemetic. But so far is the dianemetic principle from acting alone, that it is in virtue of the diorthotic principle that it assigns fifty to a man who may possibly be a millionaire and a scoundrel, and five shillings to a man who may be a pauper and a saint! And just in the same way the presence of *both* principles is indispensable to the decision of questions of a public nature. There, too, justice demands that the dianemetic principle shall act diorthotically, and the diorthotic principle dianemetically. Suppose that the suffrage is claimed by a particular class of persons whose right to it has hitherto been ignored or denied. What justice entitles them to ask the State to do is, not to create *new* rights in their favour, but to recognise rights which they allege exist in their persons already. Here, too, they claim equality before the law—they demand a fair (*i.e.*, a diorthotic) hearing. But their plea is that they are entitled to the suffrage on some *ground*, as they call it,—property, education, a hearth and a chimney, perhaps a fire, if they have it, or simple humanity. Whatever the ground may be, they demand that it should be diorthotically inquired into. But they do not dispute, except by mistake, that it must be dianemetically recognised. Even if they ask the State to proceed on the *assumption* that they all possess the ground of recognition equally, they do not ask the State to *make* it equal to them all; in other words, they do not ask it to give them means to teach them, or to make them human beings, for that would be to ask not recognition, not equality before the law, but revolution, or the abolition of the law. It was Rousseau's doctrine that all men *ought* to be equal, and not Hobbes's doctrine that all men *are* equal, and ought, consequently, to be *recognised* as such, which brought about the revolutions of last century, and which threaten us still.

Keeping this distinction in view, then, it is obvious that, if justice is to be done between nations, there must, as in all other cases in which it is called into play, be proportion between the claimant and the thing granted to him (ὅις καὶ ἐν ὅις), in order that those who are unequal may not have equal things (μὴ ίσοι οὐκ ίσα ἐξο υσι) or the reverse. But since the Peace of Westphalia, and more especially since the American and French revolutions, the tendency in international, as in national politics, has been to ignore the proportional or dianemetic principle altogether, to give exclusive sway to the diorthotic principle, and to deal with all states either as internationally equal, or else as internationally non-existent.

As regards the future, then, the question, on which the possibility or impossibility of international organisation seems to turn is this,—Can we shadow forth a European or cosmopolitan constitution, self-sustaining and self-vindicating, which shall make provision for legitimate progress and righteous development, and for inevitable retrogression, whilst it takes cognizance of existing diversities of power? To anything approaching to a confederation, in the stricter sense of a single composite state, there is, I think, the objection which exists to all confederations, and of which we have just seen the consequences so terribly exhibited, first in America and then in Germany. In a confederation there are always two forces at work,—a centrifugal force and a centripetal force; the tendency of the first of which is to pull it to pieces, and the tendency of the second of which is to centralise it till it becomes a homogeneous State. A perfect and permanent balance between these forces I believe to be a practical impossibility; and for this reason I regard all confederations as transitional forms of government. I concur, therefore, in the latest opinion of Kant, whose great mind was much occupied with this great subject before it experienced the eclipse which darkened his last days—an opinion in which he was partially anticipated by Grotius—to the effect that it is to the creation, not of a confederation, but of a Permanent Congress of Nations, or International Parliament, that we must direct our endeavours. Such a Congress, I think, would obviate the errors I have indicated, and might possibly satisfy the great desideratum of a self-vindicating international legislature, if it were constituted in accordance with something approaching the following scheme:—1*st*, That its meetings should be annual, taking place in the autumn, between the sessions of the various national assemblies; and that the places of meeting should be Belgium and Switzerland alternately, or perhaps one of the Swiss Cantons—say Geneva—set apart as neutral European ground. 2*d*, That each State should be represented by two deputies, both of whom should be present at the meetings of the Congress, but one of whom only should be entitled to speak and to vote. 3*d*, That each State be entitled to vote in proportion to its real power and importance, *for the time being*. 4*th*, That in order to fix this proportion, it be the *first* business of each Congress to ascertain the relative importance of each State on the basis,—(*a*) of population; (*b*) of exports and imports; (*c*) of free revenue. 5*th*, That each State be entitled to propose and push to a vote any question of international politics in which it might be interested. 6*th*, That each State be bound to supply a contingent of men, or money, proportioned to the number of votes assigned to it, for the purpose of enforcing the decrees of the Congress, *by arms if necessary*. 7*th*, That the representatives of any State which should make war without the sanction of the Congress be excluded from its next meeting; and that the conduct of such State be judged of in their absence, on a written statement and oral hearing of counsel, by the representatives of the other States. 8*th*, That all purely national questions be excluded from the deliberations of the Congress; but that the Congress itself should determine whether any question brought before it were or were not of this kind. 9*th*, That civil wars, as opposed to rebellions, be within the jurisdiction of the Congress; the Congress itself being entitled to judge what internal commotions possess the character of civil wars. 10*th*, That all questions brought by individual States before the Congress be submitted to it by the representatives of such States,—first *scripto*, and then *viva voce*. 11*th*, That a Judicial Tribunal be constituted, to the decision of which it should be competent for the Congress to remit any matter which it conceived to admit, demand, or to admit of, judicial determination. 12*th*, That a final appeal should lie from this tribunal to the Congress itself, in a manner analogous to that in which the judgments of our supreme courts may be carried to the House of Lords. 13*th*, That the judges of this court be appointed by the Congress, each State voting in proportion to its real weight, ascertained as above. 14*th*, That the presidents, both of the Congress itself and of the judicial tribunal, be appointed or re-elected at each meeting of the Congress, but that the ordinary judges of the tribunal should hold their offices *ad vitam aut culpam*. 15*th*, That the presidents and judges, being officers of the Congress, be paid by the Congress; but that the representatives receive no remuneration, except such as should be granted them by their respective States.

16*th*, That the expenses of the Congress be defrayed by an international tax, to be fixed by the Congress; that the said tax be proportioned to the number of votes enjoyed for the previous year by each State, and be levied by the several States on their own inhabitants.

Many provisions of a more special kind would, of course, suggest themselves were the scheme to assume a practical shape; but the preceding will sufficiently indicate its general character. A body which should take cognizance of the real power and importance of its various members would have a very much better chance of being accepted in lieu of the verdict of battle than those of a body of which all the members voted equally. The chances would then be many that individual States would gain no more by fighting than by voting; and to assume that, in such circumstances, they would in general prefer to vote, is surely to credit them with no very wonderful measure either of humanity or of wisdom.

2. On the Sophists of the Fifth Century, B.C. By Professor Blackie.

The object of this paper was to controvert the views of Mr Grote as stated in his history of Greece and in his work on Plato. Professor Blackie, while admitting that the Sophists might have been somewhat hardly dealt with by certain extreme writers in modern times, and recognising gladly the view stated by Meiners and Hegel that their teaching was an important and necessary step in the intellectual development of Greece, nevertheless maintained that the current character of the Sophists, as handed down to us from ancient times, was in the main correct; and that all that could be said in defence of their teaching amounted to no more than a slight palliation of the charges brought against them by Plato and Aristophanes, not to an acquittal. The portrait of the Sophists left us by these two great writers was substantially correct; and, if any man considered their testimony unworthy of credit, it was amply confirmed in all points by Aristotle, and Xenophon, and Isocrates in passages of their works, which had been ably analysed by Mr Cope of Trinity College, Cambridge, but which Mr Grote had either overlooked altogether, or looked at with eyes of prejudice and obliquity. Professor Blackie concluded his paper with the following five points of the Sophistical doctrine, as he gathered it from Plato:—

1. General information and alert intelligence without a philosophical basis, or a scientific method of verification. 2. The art of public speaking, considered merely as an instrument of moving masses of ignorant men with a view to political advancement, and not necessarily connected either with noble motives, earnest purpose, or business habits. 3. The exercise of a dexterous logic, which aimed at the ingenious, the striking, and the plausible, rather than the true, the solid, and the judicious. 4. A theory of metaphysics, which, by confounding knowledge with sensation, and subordinating the general to the particular, made wisdom consist rather in the urgent use of present opportunity than in the moulding of materials according to an intellectual principle. 5. A theory of morals, which, by basing right on convention, not on nature, deprived our sensual and animal instincts of the strong control of reason, and substituted for the eternal instinct of justice in the human heart the arbitrary enactments of positive law, whose ultimate sanction is the intelligent selfishness of the individual.

3. An Account of some peculiarly-shaped Mineral Concretions found near Carlisle. By Henry Barnes, M.D. Communicated by Sir David Brewster.

I have very great pleasure in presenting to the Society's museum a few very peculiarly-shaped stones or mineral concretions found near Carlisle, similar in external characters to those fairy stones found in Elwand Water, near Melrose, and described at a meeting of this Society, held 5th February 1866, by Sir D. Brewster. These stones or nodules were found about twenty years ago embedded in marl in a deep cutting at Wreay, five miles south of Carlisle, during the formation of the Lancaster and Carlisle Railway. They were found in great numbers by the workmen, but only in this particular cutting, and excited a great deal of curiosity at the time, but were soon laid aside and forgotten; and it was not until the account of those fairy stones described by Sir D. Brewster appeared, that my esteemed relative, Dr T. Barnes, F.R.S.E., remembered that he had them in his possession, and asked me to present them to the Society.

They are all of a light colour, presenting a smooth surface, and inodorous when dry. When breathed upon they emit an argillaceous odour. They vary in weight from two to seven ounces.

Table of Weights.

6 oz. 6 drs.
6 oz. 3 drs.
3 oz. 3 drs.
3 oz.
2 oz. 2 drs.
1 oz. 7 drs.

On section they are seen to be perfectly homogeneous, presenting the same uniform structure throughout, showing that the nodules on the external surface are produced by some external agency acting on the surface of the stone. They are probably formed in the same way as the fairy stones, viz., by the dropping of water containing the matter of which they are composed; but must be of great age, as the cutting in which they were found is about one hundred yards from the bed of a river. The following are the geological characters of this part of Cumberland in which they occurred. It is situated on the New Red Sandstone, but at Coathill and Newbiggin gypsum is found lying in red argillaceous marl between two strata of sandstone, and at Wreay is the commencement of the whinstone dyke which extends from that place to Renwick.

4. Note on Professor Tait's "Quaternion Path" to Determinants of the Third Order. By the Rev. Hugh Martin, M.A. Communicated by Professor Kelland.

I have read with much interest Professor Tait's "Note on Determinants of the Third Order" in the *Proceedings* of this Session (pp. 59–61), and admire the method of discovering new properties of Determinants. I am not sure, however, that the properties, when discovered, are more difficult of proof by Determinant methods, and I venture to submit the following as simple and elementary:—

The *first* property, namely,

$$\begin{vmatrix} x+x_1 & y+y_1 & z+z_1 \\ x_1+x_2 & y_1+y_2 & z_1+z_2 \\ x_2+x & y_2+y & z_2+z \end{vmatrix} = 2 \begin{vmatrix} x & y & z \\ x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \end{vmatrix}$$

is true under greater generality, and the Determinant proof is the same as for the special case.

Let

$$\begin{vmatrix}
a_{1,1}+a_{1,2}+\cdot\cdot+a_{1,n-2}+a_{1,n-1}, & \cdot\cdot\cdot, & a_{n,1}+a_{n,2}+\cdot\cdot+a_{n,n-2}+a_{n,n-1} \\
a_{1,2}+a_{1,3}+\cdot\cdot+a_{1,n-1}+a_{1,n}, & \cdot\cdot\cdot, & a_{n,2}+a_{n,3}+\cdot\cdot+a_{n,n-1}+a_{n,n} \\
a_{1,3}+a_{1,4}+\cdot\cdot+a_{1,n}+a_{1,1}, & \cdot\cdot\cdot, & a_{n,3}+a_{n,4}+\cdot\cdot+a_{n,n}+a_{n,1} \\
\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot, & \cdot\cdot\cdot, & \cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot \\
\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot, & \cdot\cdot\cdot, & \cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot \\
\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot, & \cdot\cdot\cdot, & \cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot\cdot \\
a_{1,n}+a_{1,1}+\cdot\cdot+a_{1,n-3}+a_{1,n-2}, & \cdot\cdot\cdot, & a_{n,n}+a_{n,1}+\cdot\cdot+a_{n,n-3}+a_{n,n-2}
\end{vmatrix} = \nabla$$

Add all the rows to form a new first row, namely,

$$(n-1)\,.\,\overline{a_{1,1}+\cdot\cdot+a_{1,n}},\ \cdot\cdot,\ (n-1)\,.\,\overline{a_{n,1}+\cdot\cdot+a_{n,n}}\ :$$

take the factor $(n-1)$ outside the determinant: subtract the resulting new first row from each of the others:

then add to it the sum of the others: and we have

$$\nabla = (n-1) \begin{vmatrix} a_{1,n} & a_{2,n} & \ldots & a_{n,n} \\ -a1_{,1} & -a_{2,1} & \ldots & -a_{n,1} \\ -a_{1,2} & -a_{2,2} & \ldots & -a_{n,2} \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ -a_{1,n-1}, & -a_{2,n-1} & \ldots & -a_{n,n-1} \end{vmatrix}$$

The negative signs may be removed and compensated for by the factor $(-1)^{n-1}$ placed outside the Determinant, and the first row may be made the last by multiplying again by $(-1)^{n-1}$, which counteracts the former multiplication. Hence

$$\nabla = (n-1) \begin{vmatrix} a_{1,1} & a_{2,1} & \ldots & a_{n,1} \\ a_{1,2} & a_{2,2} & \ldots & a_{n,2} \\ \cdot & \cdot & \cdots & \cdot \\ a_{1,n} & a_{2,n} & \ldots & a_{n,n} \end{vmatrix} \quad \text{Q. E. D.}$$

When $n=3$, this is the quaternion theorem in question.

The *second* formula is the well-known property of the reciprocal, and a simple proof of it will be given below.

The *third* and *fourth* are immediate translations of Quaternion expressions into Determinant forms. And I suppose there is no analytical difficulty in enlarging the number of Sir William R. Hamilton's symbols, i, j, k (though it would introduce the conception of ideal space of more dimensions than three), and thus extending the reach of the "Quaternion path" to Determinants of any order.

The *fifth* formula, in its algebraical expression, would be

$$\left| \begin{array}{lll} \begin{vmatrix} y & z \\ y_1 & z_1 \end{vmatrix} + \begin{vmatrix} y_1 & z_1 \\ y_2 & z_2 \end{vmatrix}, & \begin{vmatrix} z & x \\ z_1 & x_1 \end{vmatrix} + \begin{vmatrix} z_1 & x_1 \\ z_2 & x_2 \end{vmatrix}, & \&c. \\ \begin{vmatrix} y_1 & z_1 \\ y_2 & z_2 \end{vmatrix} + \begin{vmatrix} y_2 & z_2 \\ y & z \end{vmatrix}, & \&c., & \&c. \\ \begin{vmatrix} y_2 & z_2 \\ y & z \end{vmatrix} + \begin{vmatrix} y & z \\ y_1 & z_1 \end{vmatrix}, & \&c., & \&c. \end{array} \right| = -2 \begin{vmatrix} x & y & z \\ x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \end{vmatrix}^2$$

Now, using capitals for minors we have, by the first property,

$$\begin{vmatrix} X_2 + X & Y_2 + Y & Z_2 + Z \\ X + X_1 & Y + Y_1 & Z + Z_1 \\ X_1 + X_2 & Y_1 + Y_2 & Z + Z_2 \end{vmatrix} = 2 \begin{vmatrix} X & Y & Z \\ X_2 & Y_2 & Z_2 \\ X_1 & Y_1 & Z_1 \end{vmatrix}$$

$$= -2 \begin{vmatrix} X & Y & Z \\ X_1 & Y_1 & Z_1 \\ X_2 & Y_2 & Z_2 \end{vmatrix} = -2 \begin{vmatrix} x & y & z \\ x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \end{vmatrix}^2 \qquad \text{Q. E. D.}$$

This, of course, may be generalised like the *first* formula; and the result is

$$\begin{vmatrix} A_{1,n} & + A_{1,1} + & A_{1,2} + & \cdot & + A_{1,n-2}, \text{ \&c., \&c.} \\ A_{1,1} & + A_{1,2} + & A_{1,3} + & \cdot & + A_{1,n-1}, \text{ \&c., \&c.} \\ A_{1,2} & + A_{1,3} + & A_{1,4} + & \cdot & + A_{1,1}, \text{ \&c., \&c.} \\ \cdot\ \cdot\ \cdot & \cdot\ \cdot\ \cdot & \cdot\ \cdot\ \cdot & \cdot\ \cdot & \cdot\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot \\ A_{1,n-1} & + A_{1,n} + & A_{1,1} + & \cdot & + A_{1,n-3}, \text{ \&c., \&c.} \end{vmatrix}$$

$$= -(n-1) \begin{vmatrix} a_{1,1} & \cdot & \cdot & \cdot & a_{1,n} \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ a_{1,n} & \cdot & \cdot & \cdot & a_{n,n} \end{vmatrix}^{n-1}$$

The *sixth* formula is got by a reduplication of the proof of the *fifth*, whether the method used be Quaternion or Determinant.

As to the reciprocal, the following seems quite elementary:—

Let

$$\begin{vmatrix} yz_1 - zy_1 & zx_1 - xz_1 & xy_1 - yx_1 \\ y_1z_2 - z_1y_2 & z_1x_2 - x_2z_1 & x_1y_2 - y_1x_2 \\ y_2z - z_2y & z_2x - xz_2 & x_2y - y_2x \end{vmatrix} = \nabla$$

Multiply the first row by x_2, the second by x, the third by x_1; add all the rows for a new first row; divide the second row by x, and the third by x_1.

$$\left| \begin{array}{ccc} \begin{vmatrix} x & y & z \\ x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \end{vmatrix} & 0 & 0 \\ X & Y & Z \\ X_1 & Y_1 & Z_1 \end{array} \right| = x_2 \nabla$$

Hence

$$\begin{vmatrix} x & y & z \\ x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \end{vmatrix} \begin{vmatrix} Y & Z \\ Y_1 & Z_1 \end{vmatrix} = x_2 \nabla$$

But it is at once seen that

$$\begin{vmatrix} Y & Z \\ Y_1 & Z_1 \end{vmatrix} = x_2 \begin{vmatrix} x & y & z \\ x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \end{vmatrix}$$

Hence

$$\nabla = \begin{vmatrix} x & y & z \\ x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \end{vmatrix}^2 \qquad \text{Q. E. D.}$$

The following Gentleman was elected a Fellow of the Society :—

James H. B. Hallen, Esq.

The following Donations to the Library were announced :—

Transactions of the Highland and Agricultural Society of Scotland. Vol. I. No. 2. Aberdeen, 1867. 8vo.—*From the Society.*

Transactions of the Royal Society of Literature, London. Vol. VIII. Part 3. 8vo.—*From the Society.*

Journal of the Scottish Meteorological Society for January 1867. Edinburgh, 8vo.—*From the Society.*

Journal of the Chemical Society of London for March 1867. 8vo. —*From the Society.*

Proceedings of the Meteorological Society of London. Vol. III. No. 27. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society of London. Vol. I. New Series, No. 7. 8vo.—*From the Society.*

Monthly Notices of the Royal Astronomical Society, London. Vol. XXVII. No. 4. 8vo.—*From the Society.*

Proceedings of the Royal Geographical Society, London. Vol. XI. No. 1. 8vo.—*From the Society.*

Proceedings of the Royal Society, London. Vol. XV. No. 90. 8vo.—*From the Society.*

Proceedings of the Royal Medical and Chirurgical Society of London. Vol. V. No. 6. 8vo.—*From the Society.*

Monthly Return of Births, Deaths, and Marriages Registered in the eight Principal Towns of Scotland, January 1867. 8vo.—*From the Registrar-General.*

Quarterly Return of Births, Deaths, and Marriages Registered in the Divisions, Counties, and Districts of Scotland. No. 48. 8vo.—*From the Registrar-General.*

American Journal of Science and Arts. Second Series. No. 127. New Haven, 1867. 8vo.—*From the Editors.*

Notes on the Great Ganges Canal. By T. Login, Esq., C.E. Roorkee, 1867. 8vo.—*From the Author.*

Roads, Railways, and Canals for India. By T. Login, Esq., C.E. Roorkee, 1866. 8vo.—*From the Author.*

Historical Sketch and Laws of the Royal College of Physicians of Edinburgh, from its Institution to December 1865. Edinburgh, 1867. 4to.—*From the College.*

Bulletin de l'Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique. Tome XXIII. No. 2. Bruxelles, 1867. 8vo.—*From the Academy.*

Monatsbericht der Königlich Preussischen Akadémie der Wissenschaften zu Berlin, November 1866. Berlin, 1867. 8vo.—*From the Academy.*

Sveriges Geologiska Undersökning, pa offentlig bekostnad utförd under ledning af A. Erdmann. Liv. 17–21 (with maps). Stockholm, 1866.—*From the Geological Commission of Sweden.*

Nova Acta Regiæ Societatis Scientiarum Upsaliensis. Vol. VI. Fascs. 1. Upsala, 1866. 4to.—*From the Society.*

Monday, 1*st April* 1867.

SIR DAVID BREWSTER, President, in the Chair.

The following Communications were read:—

1. On the Analysis of Compound Ethers. By W. Dittmar.

In many cases the best guarantee of the purity of a chemical substance is the method by which it has been prepared. If the processes are well devised and carefully conducted, they constitute in themselves a qualitative analysis on a large scale, the exactitude and reliability of which go far beyond what could be obtained by ordinary testing. This, however, does not apply to many organic preparations, and is eminently inapplicable in the case of compound ethers. If in the preparation of such an ether, we start with a pure alcohol and a pure acid, and carefully distil, wash, and redistil the ether produced, the product ultimately obtained may contain considerable quantities of alcohol, free acid, and water. The purity of a compound ether can be established only by direct experiment. Free acid is easily tested for, and even quantitatively determined by the well-known acidimetric processes; the presence or absence of water may be proved by an elementary analysis, but an admixture of alcohol is not easily established. An elementary analysis would, in a majority of cases, show very little, because the difference between the percentages of carbon in the ether and alcohol respectively, is usually too small to admit of basing upon a small fraction of that difference anything like an exact calculation. Thus, for instance, acetate of ethyl contains 54·54 per cent. of carbon, and alcohol 52·18 %—the difference is 2·36; a decrease of 0·1 % in the carbon would therefore correspond to an admixture of about 4 per cent. of alcohol.

Many years ago F. Mohr proposed a method for quantitatively testing the officinal "æther aceticus," which consisted in heating the ether in a closed vessel, with an excess of standard alkali, and determining the amount of alkali saturated. The method was in 1863 extended and improved upon by Berthelot, who seems to have employed it extensively in his researches. The standard alkali used by Berthelot was caustic baryta, which he heated with the ether under examination in a glass tube. On attempting some time ago to employ Berthelot's method for testing, what I had good reason to look upon as very pure formiate of ethyl, I was surprised by obtaining perfectly inexplicable results; and on subjecting his process to a critical examination, I found that the discrepancies in my results arose from the action of the baryta solution on glass. When baryta water was heated to 120° C. in sealed-up tubes, and kept at that temperature for about twenty-four hours, the glass was found to be strongly attacked, and the titre of the baryta solution considerably altered. How Berthelot managed to obtain exact results is more than I can explain. Seeing that baryta was not a reliable reagent for the titration of ethers, I tried a solution of carbonate of sodium, hoping that it would not appreciably act on hard glass, but without success.

A solution of the carbonate, when heated in a sealed-up tube, took up enough of alkali from the glass for its titre being increased by about $\frac{1}{40}$th. At last I found that, of all the available alkaline solutions, caustic ammonia was the only one which could be safely heated in sealed-up glass tubes. In order to see now if ammonia also was capable of completely decomposing compound ethers, a series of experiments was instituted, in which measured quantities of standard ammonia (containing about 17 grms. NH_3 per litre) were heated with acid acetate of ethyl, containing a known quantity of acetic acid. Such mixtures were procured by heating to 130°—140° C. &c., in sealed-up tubes, weighed quantities of glacial acetic acid, with a large excess of alcohol, a direct experiment having shown that, after a few hours heating, 60 °/₀ of the acid employed was etherified. The amount of ammonia saturated by the acid, after it had passed into the state of ether, was compared with that which the same quantity required when mixed directly with the alkali. Of the results obtained in this manner some came surprisingly near the truth, others differed by a per cent., and some even more; this I can only explain by the fact well known to chemists who are familiar with titrimetric analysis, that in the saturation of a weak acid with ammonia the point of neutrality is not by any means well marked. It may be, also, that in some cases the ethers had not been completely decomposed. Although the conditions under which this method would be sure to give exact results might, perhaps, be established by an extended investigation, I preferred to go back to using baryta-water, as recommended by Berthelot, substituting only for the sealed glass tubes a copper digestor, soldered with sterling silver, and provided with a conical copper stopper, which could be securely fastened by means of a screw. The stopper kept perfectly tight, even under a pressure of two atmospheres, as was shown by charging the digestor with water, weighing the arrangement, keeping it at 120° C. for about four hours, and weighing again. There was not any loss of weight observable by a balance turning with two centigrammes.

The liquid obtained by heating in the digestor a mixture of acetate of ethyl and an excess of baryta-water, did not contain any appreciable trace of copper. After these facts had been established, a number of experiments were made similar to those carried out for testing the ammonia method. The amount of baryta taken up by a weighed quantity of partially ætherified acetic acid was found to be about $\frac{1}{80}$th to $\frac{1}{100}$th less that what the same quantity of acid would have saturated when directly mixed with the standard alkali. This must be looked upon as a pretty satisfactory approximation in experiments of this kind. The method would, no doubt, give much more exact results if the excess of baryta was not titrated directly, but first precipitated by carbonic acid, and then alkalimetrically determined. The undecidedness of the end-reaction observed in titrating a weak organic acid with an alkali would thus be completely eliminated. I am now occupied with experiments in this direction.

It was only after the greater part of the facts communicated in this notice had been established that I first saw Mr Wanklyn's paper "On the Titration of Ethers" in the Chemical Society's Journal. Mr Wanklyn uses alcoholic potash for decomposing the ethers, and obtains very satisfactory results. But he extended his experiments to such substances only which can be safely heated in an open flask, and which are easily decomposed by a short digestion with alcoholic potash. When alcoholic potash is heated to 100° C. in sealed glass tubes for about twenty-four hours, the glass is so strongly attacked that there is a regular layer of silica formed.

I cannot conclude without acknowledging the great assistance which my friend Mr Cranston gave me in carrying out my experiments.

2. On a Derivative of Meconic Acid. By Messrs James Dewar and William Dittmar.

The meconic acid group of substances has always been regarded as peculiarly interesting. Situated, as it is, on the ill-defined limits of the fatty and aromatic compounds, and exhibiting interesting isomeric relations with other organic substances, the structure and derivatives of the whole group afford ample scope for theoretical speculation. Meconic acid has always been considered a tribasic acid, which, by the successive elimination of two molecules of carbonic anhydride, yields first a dibasic and then a monobasic acid. But chemists now know that the basicity of an acid may be less than its atomicity, and that even the former cannot be deduced from the composition of one or two isolated salts, but only from a comprehensive view of all the salts and ethers of the acid. As now a general review of the salts and ethers of meconic acid seems to point to an acid with an atomicity greater than its basicity, and as any additional proof of this constitution would help to explain many abnormal decompositions in the series, the authors have investigated the action of the general reagents on these compounds that enable us to distinguish between the basic and alcoholic hydroxyls. In this paper we communicate to the Society some of the results obtained in the course of our experiments, as a recent paper, by Baron von Crofft, on the action of nascent hydrogen on the members of this group, shows that other chemists are working in the same direction. The introduction of hydriodic acid and pentachloride of phosphorus as general reagents in organic chemistry has been productive of the happiest results, through the easy separation of the water residue, HO. By their use we have obtained a very complete knowledge of the relation of acids, alcohols, and hydrocarbons, and we now await the discovery of some reagent that will separate the ammonia residues with as great ease, to obtain a more precise knowledge of the structure of the organic alkaloids.

When meconic acid is treated with hydriodic acid of constant boiling point at 150° C., carbonic anhydride is evolved, and large quantities of free iodine liberated. No definite compound could be separated from the products of this decomposition. As the first action of the hydriodic acid was to form comenic acid, and as many actions succeed with concentrated hydriodic acid that are unmanageable with the dilute, we attempted the reduction by the action of a saturated solution of hydriodic acid on comenic acid. As Berthelot has lately shown that the action of concentrated hydriodic acid, at high temperatures, on mono- and bi-basic acids of the fatty series, regenerates the hydrocarbon from which they were derived, the formation of a hydrocarbon in this reaction was not impossible.

But the effect of hydriodic acid on this group is totally different from its action on the fatty series. If comenic acid and concentrated hydriodic acid are heated to upwards of 200° C., large quantities of free iodine separate out, mixed with a considerable quantity of free carbon. Hydriodic acid, therefore, is inapplicable as a reducing agent on these compounds.

Seeing that no definite compound could be obtained by the agency of hydriodic acid, the action of pentachloride of phosphorus did not look very promising. Under the influence of this reagent, however, the acid sustained a perfectly regular decomposition, and did not break up in the way one would have anticipated from its general instability in presence of powerful reagents. If meconic acid is treated with three molecules of pentachloride of phosphorus, hydrochloric acid is slowly given off in the cold; and if the retort containing the substance be heated to 100° C., the reaction takes place with great rapidity, torrents of hydrochloric acid are evolved, and oxychloride of phosphorus (PCl_3O) distilled over. In order to separate the oxychloride of phosphorus, the whole was heated for some hours to 130° C. in a current of dry carbonic anhydride. Terchloride of meconyl remained as an intensely red, non-volatile, semi-solid substance, fuming in air, and decomposible by water, with the formation of an intensely dark-brown liquid. Several organic analyses of this substance were made, but as it was found impossible to free it from all traces of phosphorus, perfectly agreeing results could not be obtained.

	Found.	The formula $C_7HO_4Cl_3$ requires
Carbon, ...	31·5	32·9
Hydrogen, ...	0·7	0·4
Chlorine, ...	44·5	41·6

As analysis did not give a satisfactory proof of the carbon group remaining entire in this reaction, a direct experiment was made with the view of estimating the amount of carbonic anhydride evolved. For this purpose a special apparatus was devised, by means of which the amount of any permanent gas produced during the reaction could be estimated. To effect this, the retort containing the substance was connected with a tubulated receiver, to condense the oxychloride of phosphorus, and this joined to a small gasometer containing a saturated solution of chloride of sodium.

During the action we did not observe any gas collecting in the receiver. After the reaction the gases in the retort and condenser were swept into the gasometer by a current of dry hydrogen. Any hydrochloric acid gas was immediately absorbed by the water, and the residual gases were then made to pass through a series of U tubes filled with soda-lime, in order to estimate the carbonic anhydride by weight. Only a trace of carbonic anhydride could be detected; nothing like a molecule was evolved.

When the terchloride of meconyl was treated with water, hydrochloric acid was produced with much frothing, and the whole dissolved to an intensely brown liquid. When this action took place in the apparatus formerly described, large quantities of carbonic anhydride could easily be detected. Many attempts were made to produce definite salts of the acid formed in this reaction, but without success. When the acid liquid was thrown upon a dialyser, the whole of the hydrochloric acid diffused out; a dark brown solution of the acid remained. This acid solution, when boiled with strong nitric acid, in presence of nitrate of silver, produced chloride of silver, and is, therefore, a chlorinated compound. Although the acid is a lower derivative of meconic acid, the presence of chlorine shows that the three atoms of chlorine replacing the water-residues are not retained with equal degrees of force. The dark brown solution was completely decolourised by the action of sodium amalgam.

When comenic acid was treated with pentachloride of phosphorus, a chloride more intractable than that formerly described was obtained.

As pyromeconic acid contains the simplest form of the characteristic nucleus of the whole group, a knowledge of the structure of this substance would throw great light on the constitution of the meconic acid series. If a careful examination be made of the general properties of pyromeconic acid, we can hardly characterise it as a real acid. No doubt salts can be formed, but with great difficulty; and the fact of it not combining with the alkalies or alcohol radicals, shows that it bears a great analogy to pyrogallic acid. If we compare the formulæ of pyromeconic and pyrogallic acids, they would appear to be members of a homologous series; and as we know by synthesis that pyrogallic acid is trihydroxyl-benzol, the pyromeconic acid may be looked upon as bearing the same relation to a hydrocarbon, C_5H_4, below benzol. From our general knowledge of this class of compounds we would expect the formation, by the action of pentachloride of phosphorus, of a chloride of a hydrocarbon. We investigated this reaction on the small quantity of pyromeconic acid we had at our disposal. When pyromeconic acid, in presence of oxychloride of phosphorus, was heated in a sealed tube to 200° C. with an excess of pentachloride of phosphorus, and the result of the action treated with water, a brown oil separated out, which, when distilled, yielded a colourless oil that boiled above 200° C. This substance did not fume in the air, and remained in water without dissolving for days. The analysis gave somewhat anomalous results, the percentages of its constituents agreeing very exactly with the formula $C_{10}H_5Cl_9O_3$. This highly chlorinated substance seems to approach nearly to the chloride of a hydrocarbon.

Unfortunately, pyromeconic acid is a substance which cannot be easily investigated, as it is extremely difficult to procure in any quantity. In the course of our experiments we obtained only one per cent. of pyromeconic from meconic acid, so that until a better process for preparing this substance is discovered, it must remain an open question whether pyromeconic acid is a lower homologue of pyrogallic acid.

3. On the Action of Ammonia on Dichloracetone. By Dr A. Crum Brown.

This paper contains some further details of the properties and composition of the substance mentioned in a former note (*Proceedings*, vi. 75).

The substance is produced by the action of dry ammonia gas on dichloracetone. A low temperature favours its formation. It forms colourless needles, generally radiating from central points. It is extremely unstable, and can only be preserved in an atmosphere of dry ammonia. In *vacuo* over sulphuric acid, even at a temperature of 0° C., it decomposes into ammonia, dichloracetone, and a viscous substance, which has a smell recalling that of acetamide. The same decomposition takes place in dry air. Hydrochloric acid converts it into dichloracetone and chloride of ammonium. It may be fused in an atmosphere of dry ammonia, and sublimes readily at temperatures far below its fusing point. The point of fusion was found to be about 45° C. When exposed to a slightly higher temperature it boils with partial decomposition, leaving a slight trace of chloride of ammonium. Owing to the readiness with which it decomposes, great difficulties were experienced in its analysis, and the results have hitherto been somewhat discordant. They lead to the formula, $C_3H_{10}Cl_2N_2O$, or $C_3H_4Cl_2O + 2NH_3$, and it is possible that it may be the representative in the acetic series of the hydrochlorate of flavine.

The author is at present engaged in the further examination of this substance and the products of its decomposition.

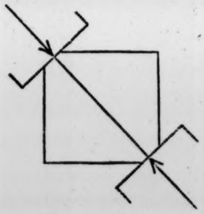
4. On Centres, Faisceaux, and Envelopes of Homology. By Rev. Hugh Martin, M.A. Communicated by Professor Kelland.

5. On the Effect of Pressure upon Rock Salt and Iceland Spar. By M. Reusch, Professor of Natural Philosophy in the University of Tubingen. Communicated by Sir David Brewster.

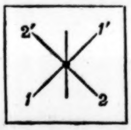
Sir David Brewster,
à Edinburgh.

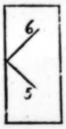
Monsieur,—Les semaines passées j'âi trouvé quelques faits dans le sel gemme et le spath d'Islande, que je prends la liberté de vous communiquer, parceque je m'imagine, qu'il n'y a personne au monde, qui saurait mieux apprécier la valeur des petites choses qui se sont offertes à moi.

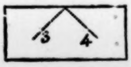
Dans le sel gemme il y a un clivage ou passage multiple, omis à tort par les minéralogistes, qui jouit des propriétès singulières et qui jetera peut être quelque lumière sur le phénomène, de la "polarisation lamellaire." Ce passage suit les faces du *granatoëdre* ou dodecaëdre régulier. En pressant un morceau carré, dont deux arètes opposées sont enlevées par la lime, on obtient par une pression modique un passage brillant suivant la diagonale. Mais on peut avoir les six passages dodecaëdriques tous à la fois en



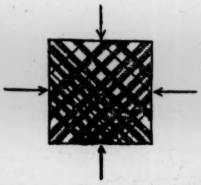
posant un poinçon conique sur le milieu d'une plaque, et en donnant dessus un petit coup d'un marteau leger. Vous trouverez au point frappé une étoile à huit bras, dont quatre tiennent au clivage ordinaire, 1 et 2 au clivage dodecaëdrique; et en regardant par les faces latérales vous trouverez les autres passages 3, 4, 5, 6. Ce petit coup a de plus déterminé suivant les six plans dodecaëdriques, qui passent par le point frappé, des *condensations permanentes*, cause de phénomènes de polarisation bien connus par vous ("Treatise on Optics," page 281, 282). Les six directions, suivant lesquelles les condensations se font avec la plus grande facilité paraissent être parallèles aux grandes diagonales des rhombes du dodecaëdre.

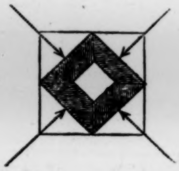


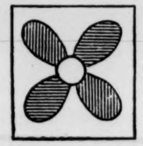




En pressant des pièces convenables sur les faces du cube ou mieux suivant quatre faces limées suivant le granatoëdre, on obtient dans la lumière polarisée des phénomènes qui rapellent, quoique imparfaitement, ceux de la polarisation, lamellaire, car jamais on ne réussira à réaliser un état de compression uniforme, indispensable pour avoir les effets de l'alun. La meilleure expérience, que j'aie pu trouver est la suivante: on perce un trou de quelques millimètres dans une plaque carrée, en tournant le foret (a métal) doucement entre les doigts. Avec la plaque sensible de gÿpse on a une très jolie fleur, due aux condensations prédominantes suivant les diagonales.







Sur les faces octaëdrique du spath fluor, attaquées par le poinçon, j'ai plusieurs fois observé des clivages normaux aux cotés du triangle isocèle, qui correspondent aux surfaces du granatoëdre. Sur l'alun, dont je n'avais que de très mauvais échantillons, je n'ai encore rien vu de distinct, mais je ne manquerai pas de poursuivre mes recherches. En attendant je suis porter à soupçonner, que la "polarisation lamellaire" pourrait être due aux condensations permanentes et uniformes suivant les passages dodecaëdriques, les pressions êtant dues ou à des forces extérieures, ou à l'act de la cristallisation même. De cette manière je ne pense pas être en désaccord avec les vues, que vous vous êtes formées sur la véritable cause de ces phénomènes.

Quant au spath d'Islande je prends la liberté de vous rappeler vos observations sur cette substance (Treat. on Optics, pp. 254–256, et pp. 349–351); de plus je vous prierai de jeter un coup d'oeil sur un mémoire de Fr. Pfaff à Erlangen, dans Poggendorff's Annalen, band 107, p. 336, et band 108, p. 599. En rapprochant ces deux choses on est poussé vers ce résultat singulier, qu'il doit être possible, *de faire naitre des " twin-films,"* dans ce cristal par une pression suffisante. Or c'est ce que j'ai fait par douzaines de fois dans le dernier temps. On prend un prisme de spath, rhombique ou rhomboidique, on y lime des surfaces planes parallèles et normales aux arètes longues du prisme, on y colle des petits cartons et l'on met le prisme dans une presse à machoires parallèles. En pressant doucement vous aurez un à trois passages, correspondant au rhomboëdre obtus, et ces passages ne sont pas ordinairement des clivages, mais de véritables " twin films." Ce fait singulier m'a rappelé l'albite, le labrador, qui sont si terriblement maclès (twin films) et pourrait donner quelques indication sur la cause de la formation de differents twin-cristaux dans la nature. Quant aux twin-films du spath d'Islande je suis persuadé, qu'il sont tous dûs à une pression extérieure soit dans le lieu de leur naissance, soit dans les mains de celui qui maltraite les cristaux en les clivant.

Voilà Monsieur! ce que j'ai voulu vous communiquer. Ce sera sans doute peu de chose dans vos yeux, qui ont tant vu; mais dépuis long temps j'ai suivi vos traces,* et étudié vos travaux, et toujours, j'ai songè à vous prèsenter quelque chose, qui fût digne de Vous. Puissé-je avoir réussi!—Agréez Monsieur l'assurance de ma plas haute considération, votre très humble serv.

REUSCH,
Prof. der Physik an der Universität.

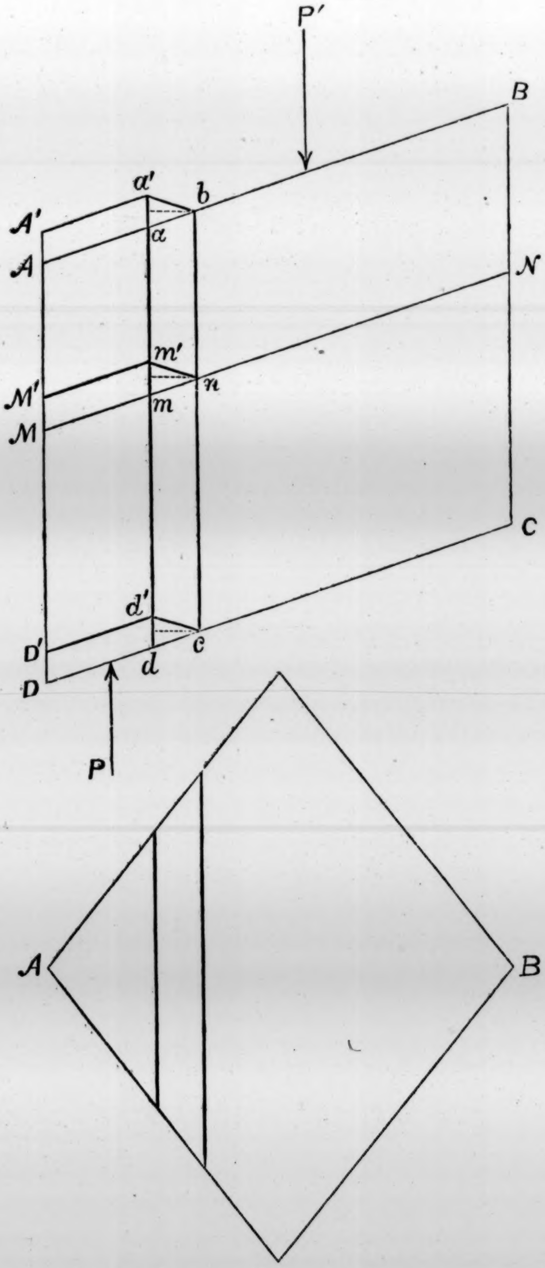
TÜBINGEN (WÜRTEMBERG),
18 *März* 1867.

---

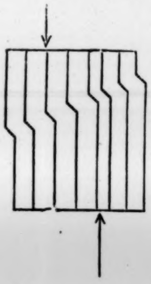
* Poggendorff's Annalen, *Ueber das Schillern gewisser Krÿstalle*, band 116, p. 392; band 118, p. 256; band 120, p. 95. *Ueber den Agat*, band 123, p. 49. *Ueber den Hÿdrophan*, band 124, p. 431.

TÜBINGEN, 27 *März* 1867.

MONSIEUR,—Je m'empresse à repondre aux observations justes, dont vous avez daigné ma prèmière communication.



Quant à la production des “twin films” dans le spath d'Islande, je tache de l'expliquer de la manière suivante: soit ABCD la section principale d'un rhomdoëdre de spath, qui est soumis à des pressions parallèles PP′ non directement opposées; il y aura dans une certaine partie *abcd* une tendance de glissement, qui finira par amener toutes les molécules *ab*, *mn*, *dc*, dans les nouvelles positions d'équilibre *a′b*, *m′n*, *d′c*, de sorte qu'une série de molecules, situées d'abord sur la ligne M*mn*N, se trouve transportée sur la ligne brisée M′*m′n*N. En rêalitê les parties *a′b*, *d′c*, sont souvent tellement bien planes, qu'elles donnent des images mésurables au goniomètre.



Si vous pressez un petit morceau de bois suivant les fibres, vous avez un phénomène analogue, parceque jamais la pression ne sera également répartie sur les faces pressées. Or, je dis que la lame *a′bcd′* est hémitrope, car en la rétournant autour d'une normale de 180° elle viendra se replacer dans la position primitive *abcd* (Miller, *Treat. on Crist.*, chap. viii. 230.) La manière, dont les minéralogistes expliquent les "twin crystals" n'est qu'une fiction géométrique, qui malheureusement n'a aucun rapport avec la structure intime des cristaux. Le sel gemme et le spath sont peut-être appelés á donner quelque lumière sur la merveilleuse charpente des cristaux.

Ce n'est pas à tort que le mot *passages* Vous a choqué. En français je n'avais pas d'autre mot à ma disposition; en allemand je les appelle "Gleitfläche" (*sliding plane*), car cette nouvelle espèce de clivage est réellement très différente des clivages ordinaires. Il est vrai, qu'une pression suffisante et poussée jusque à la séparation des molécules, peut produire des clivages miroitants dans le sel gemme et le spath; mais ce qui se passe dans les "sliding planes" *avant la rupture*, me parait être tout autre chose que ce qui s'opère dans un clivage ordinaire. Je soupçonne, que suivant ces plans, qui sans doute existent dans tous les cristaux, les molécules sont singuliérement disposées, non à se séparer, mais à prendre dans des directions déterminées des nouvelles positions d'équilibre sous l'influence de pressions extérieures, et cela sans solution de continuité. Voilà un problème qu'il s'agit d'approfondir et auquel je crois a peine avoir touché.

La preuve de ce que les lames, dues à la pression, ne sont pas des clivages, mais bien des véritables twin-lames, est très simple.

1°. En observant dans une telle lame l'image réfléchie d'une ligne horizontale, la reflexion s'opérant dans un plan vertical, normal à l'arête obtuse du rhomboëdre, vous verrez la même bifurcation de la ligne observée, que dans une twin-lame naturelle. De plus vous aurez les quatre images d'une flamme, dont deux ordinairement sont colorées (votre Treat. on Opt. p. 350, 351.)

2°. Vous taillez des plans normaux à l'axe dans une pièce, qui par la pression a gagnè une twin-lame, ou vous pressez la pièce après la coupe (expérience de Fr. Pfaff), et vous verrez entre les tourmalines les mêmes phénomènes, que dans un morceau taillè, possédant une lame naturelle (votre Optics, p. 254.)

J'espére Monsieur! que cette exposition sera propre à dissiper quelques doutes et objections, que ma première lettre pourrait avoir laissées dans votre esprit.

Il-y-a dèja quelques semaines, que j'ai communiqué mes observations aux Messieurs Dove et G. Rose à Berlin, pour être présenteés par eux à l'academie. Il parait que ces savans distingués mettent beaucoup de temps à examiner sérieusement mes résultats; car je suis encore sans reponse, mais bien sûr d'en avoir avec le temps. C'est pourquoi l'intéret, avec lequel le Nestor des Physicians a bien voulu recevoir ma communication, m'a été d'une satisfaction toute particulière. Monsieur, je vous remercie beaucoup de votre bienveillance et je vous prie, de faire tout ce que vous jugerez à propos pour publier les petites choses, que j'ai mises dans vos mains. Les deux "brief abstracts" hautement intéressants que vous avez eu la bontè de m'envoyer, m'ont fait un grand plaisir; je ne manquerai pas de répéter vos expériences, Les memoires mêmes se trouveront sans doute dans les Transactions d'Edinburgh.—Agreéz Monsieur, l'assurance, de mon plus haut éstime, votre très devoué,

REUSCH.

Sir DAVID BREWSTER, Edinburgh.

The following Gentleman was admitted a Fellow of the Society:—

HENRY DIRCKS, Esq., C.E., F.C.S.

The following Donations to the Society were announced:—

Journal of the Asiatic Society of Bengal. Part 2. 1866. Special No. Ethnology. Calcutta, 1866. 8vo.—*From the Society.*

Proceedings of the Royal Irish Academy. Vol. IX. Part 4. Dublin, 1867. 8vo.—*From the Academy.*

Transactions of the Royal Irish Academy. Vol. XXIV. Parts 7, 8. (Science.) Dublin, 1866–67. 4to.—*From the Academy.*

Verhandlungen der Vereins für Naturkunde zu Presburg, VIII., IX. Jahrgang. 8vo.—*From Professor E. Mack, Presburg.*

Bulletin de la Société de Geographie. Fevrier, 1867. Paris, 1867. 8vo.—*From the Society.*

Abhandlungen der Koniglichen Akademie der Wissenschaften zu Berlin. 1865. Berlin, 1866. 4to.—*From the Academy.*

Ueber die Verschiedenheit in der Schädelbildung des Gorilla, Chimpansé, und Orang-Outang, vorzüglich nach Geschlecht und Alter, nebst einer Bemerkung über die Darwinsche Theorie (with plates), von Dr Th. L. Bischoff. Munchen, 1867. 4to. —*From the Royal Academy, Munich.*

Monday, 15th April 1867.

Sir DAVID BREWSTER, President, in the Chair.

The following Communications were read:—

1. On the Nature and Character of European Winter Storms, with the best means of giving Warning of their Approach.

By R. Russell, Esq.

The object of this paper was to show the true character of storms, illustrated by those of 2d, 3d, and 4th December 1863. It was pointed out that the mode usually adopted of laying down the isobarometric lines was calculated to present an erroneous view of their figure or form. The laying down representative lines in round numbers of 5 millemetres in each, or in two-tenths of an inch of barometric readings, lead deceptively to the conclusion that the areas of least pressure were circular or elliptical.

It was then shown that the lines of equal pressures were ribbed into the *latitudinal* line of minimum barometer, which was usually found running north and south, sometimes nearly straight, but often curved, with its convex side towards the east. The minimum line of barometer was easily fixed by consulting the self-registering barometers. The minimum line of barometer was shown to have been on the meridian of London at 8 A.M. of the 3d December, and apparently nearly straight from Algiers to the Orkney Islands. The barometer along the line of minimum barometer gradually descended from upwards of 30 inches in Algiers to 29 inches a little to the south of London. From London to the Shetland Islands the minimum barometer was isobarometric in its character —the pressure varying little over a distance of 600 miles. The isobarometric lines were shown to run parallel to each other over Spain, the Mediterranean, and south of France, and joined to the minimum line at an obtuse angle. Where the difference of pressure on the latitudes from the middle of France to the south of England was considerable, they were ribbed in from both sides at acute angles. Where the minimum line assumed the character of an isobarometric line, the isobarometric lines on the east were nearly straight and parallel to each other. On the west, they were much of the same character, especially about a hundred miles west of the minimum line. It was shown that curved lines could not be put in over France on the 3d December storm, according to the barometrical readings as given in the Paris Bulletins.

The isobarometric lines were shown to have been similar in their character on the morning of the 2d; that, however, they were flatly ribbed into the minimum line of barometer over France and England, and corresponded with the diagrams of the self-registering barometers at Oxford, Kew, and Greenwich. The effects of the storm of the 3d, then out into the Atlantic, were shown on the lines in contrast with those of the latter date.

It was shown that the winds on the *west side* of the minimum barometer were from the west and north-west—the only exception to this being over the north of France and south of England, where south-west winds were observed at those stations where the isobarometric lines were kneed in towards the minimum line of barometer. At those places they mostly blew right across the isobarometric lines. At other places to the west the winds blew obliquely or directly across these lines towards the minimum barometer.

Along the line of minimum barometer, where it was almost isobarometric, the winds either lulled or fell down to a calm on its passage from west to east, both on the 2d and 3d December. On the morning of the 2d, calms and light winds prevailed for several hours from the north of Scotland to the south of England. The winds to the east were shown to have blown from easterly quarters obliquely or directly across the isobarometric lines towards the calms and line of low barometer—the winds to the west, across the isobarometric lines, also towards the calms and line of low barometer.

The winds on the west were comparatively cold and dry, raising the barometer, while on the east they were relatively moist and warm, and attended with rains and falling barometer.

Over the south and easterly parts of France the winds were from southerly quarters up to the line of low barometer, which apparently ran nearly north and south at 8 A.M. on the 3d betwixt Rochefort and Bordeaux. The winds in the south-east of the line were then light, but blowing across the isobarometric lines, but in the north strong, where the difference in the pressure on the latitudes became great.

The storm of the 2d December travelled rapidly from west to east from the north of Scotland to the south of Europe—the barometers all rising on the passage of the line of low barometer, very sharply as far north as Utrecht, Munich, and Vienna; as well as at Geneva, Marseilles, and Rome. It reached Rome and Ancona at 8 A.M. of 3d, with wind and rain. The self-registering barometers at Prague and Cracow showed that the rise was only slight at both these places.

During the 2d the barometers continued to fall slowly over Norway and Sweden. On the morning of the 3d, however, after the barometers had again fallen rapidly after midnight over the south of Europe, the rise of the barometer was general over the whole of Europe.

The line of low barometer was over Liverpool at 6 A.M. of 3d; Oxford at 6.45; Nottingham at 7.45; Greenwich at 8.12; Brussels at 11; Utrecht at noon; Geneva at 4.20; St Bernard, Marseilles, and Munich at 6; and Prague at 8. At 9 P.M. the barometers from Haparanda, at the head of the Gulf of Bothnia, to about 50 miles east of Prague, attained their minimum. It passed Vienna at 10, Buda at midnight, and Cracow at 1 A.M. of the 4th. On this occasion the line of low barometer was largely curved on its passage over the Alps, having only reached Florence at 9 A.M. of the 4th, and Rome at 2 P.M. The effect of the Alps in sometimes delaying the RISE of the barometer in Italy, but not the FALL, was formerly pointed out by the author to Signor Matteucci—the cause of the Alps and mountains of Norway in sometimes delaying the rise of the barometer, is alluded to as an interesting fact for discussion.

The storms of 2d and 3d December both travelled rapidly from west to east over Europe. They were shown to have had no such erratic course as some had been led to suppose. That of the 3d, in which the rise of the barometer was general over Europe, was shown, by the self-registering barometers and observations, taken at different hours, to have travelled with great rapidity: Over Norway and Sweden it was upwards of fifty miles an hour, and about the same from Greenwich to Cracow. The rate of motion was less in the lower latitudes, being 45 miles an hour from Paris to Munich, 37 from Rochefort to Geneva, 34 from Bordeaux to Marseilles, and only 30 miles an hour from Florence to Rome.

The winds blew obliquely or directly towards the low barometer when it was to the westward, and in the opposite direction when it was to the east. The bending of the isobarometric line in its passage across the Alps produced a hurricane from the north at Rome after 2 P.M. of the 4th, in consequence of the westerly cold current being pressed down towards the south by the higher barometers then existing in the north.

The easterly progression of storms is due to the westerly current that generally prevails, as an upper or under current in extra-tropical latitudes. Henry and Herschel consider this a counterpart or return of the trades of the tropics. The author is not satisfied with this explanation, but in the meantime cannot give a better.

The high west winds at Liverpool and all places to the south, on the morning of the 2d December, was caused by a descent of the upper westerly current, and they blew with great force for four or five hours at the earth's surface. There was a calm behind them and a calm in front. The self-registering anemometers at Liverpool and Utrecht, which are not far from being on the same latitude, showed that the strong winds from the west lasted about the same time at both places. It was merely a repetition of the same phenomena along the same latitude.

On the 3d the westerly wind prevailed more generally on the surface of the earth, modified into north and north-west winds, as the pressure required to be equalised. The winds over any great space do not blow to a centre, but to the calms and light winds along the line of minimum barometer. It was shown that a minimum point or space of barometric pressure existed, on the line of low barometer, over the south of Scotland and north of England on the 3d December. This caused a centripetal action of the winds as it passed from west to east. They blew to the low barometer from the N.E. over the Firth of Forth, and gradually veered round to N. and N.W. as the low barometer passed on toward the east. The winds to the south, on the contrary, veered from S.E. round by S. and S.W., till the arrival of the cold north-westerly current.

The minimum barometer is propagated, and cannot strictly be said to travel. It is merely the western edge of the south-westerly current, which prevails as a middle current, probably not more than 15,000 feet from the earth's surface. It is this south-westerly current that brings the moisture and comparatively high temperature which is found *east* of the line of low barometer. The easterly winds, which are of no great depth, ascend into this south-westerly current, not over a given elongated space, as Espy supposed, but over the whole area where they blow and the barometers are falling. The existence of south-west winds on St Bernard's, 8200 feet above the level of the sea, while easterly winds prevail over the plains of Europe during the falling barometers in the December storms, is appealed to as decisive of the views which have been long held by the Author on this point.

The latitudinal line of minimum barometer represents that space where the air from the surface of the earth to the top of the atmosphere is warmest on any latitude, and consequently lightest. The air is abnormally heated by the condensation of vapour in its upper beds, which has the effect of propelling the air from the south-west above, and from easterly quarters below. The heated air of the upper surface of the south-west middle current is swept off towards the east, and causes the high pressure in Eastern Europe, such as prevailed there on the morning of the 2d December, when the barometer was low in Western Europe. The same principle that regulates the sea-breeze on our coasts in summer, regulates the motions of the winds in storms.

The south-westerly current that blows above in the high latitude is usually felt at the surface in France and the Mediterranean eight or ten hours before the passage of the minimum barometer. It blows obliquely across the isobarometric lines, and, in contradistinction to Espy's views, obliquely *from* the line of minimum barometer. When the difference of pressure is great betwixt the isobarometric lines, the wind blows violently from the south, at first changing to the south-west, on the passage of the low barometer, and then to the west and north-west, becoming a part of the general cold and dry current which raises the barometer.

The cold and dry current prevailing from the west, causing the rise of the barometer, imparts form to the line of minimum barometer. This line is of great length, and frequently nearly straight, and for obvious reasons, when bent, it can only be largely bent with its convex side towards the east. It is often greatly curved in the slow-moving storms of autumn, when north-easterly rainy winds are largely developed on the north-eastern part of storms.

In regard to storm-warning, it was contended that, as storms all issued out of the Atlantic, a day and night watch at Valentia, on the west coast of Ireland, was indispensable to give warning of such rapidly-moving storms as those of December 1863. That storms all travelled from west to east was established eighty years ago, through the labours of the Meteorological Society of the Palatinate, and had been completely verified by the experience of Signor Matteucci, the distinguished director of the Meteorological Department in Italy. Every country in Europe must watch the development of storms as they pass to the east on the latitudes on which they are situated. It was shown that it is highly probable that great breakings up in our weather may be telegraphed from Newfoundland.

2. On the Vapour Lines in the Spectrum. By Sir David Brewster, K.H., F.R.S.

In the year 1842 I discovered that the luminous and brilliant lines in the spectrum of certain flames, since called *vapour lines*, corresponded to certain dark lines in the solar spectrum.

This observation was made for the first time by the spectrum produced by the deflagration of nitre, and I afterwards found that this was a property belonging to every such flame.*

This result was obtained from experiments made at St Andrews in 1842, on nearly 180 substances, deflagrated in a platina cup by a mixture of oxygen and coal gas. A notice of these experiments was read at the meeting of the British Association at Manchester in 1842. The journal containing them was laid before the Physical Section, and one or two of the more interesting results were published in the reports of the Association for that year. The object of these experiments was merely to discover new facts for future investigation, and hence the place of the bright lines was simply estimated by the eye. Other pursuits, of a less laborious kind, prevented me from determining the exact places of these lines in those flames where their number and position were most remarkable, but this will now be better done by some of those numerous observers who are working so successfully with the spectroscope.

The following specimens of these observations will show their limited character, and how far they may be useful and suggestive to future observers :—

1. In the *Chlorides of Tin* and *Lead.* The whole spectrum was covered with splendid lines, the double line D being conspicuous.

2. In the *Ammonio-Chloride of Platinum.* The colour of the flame *yellow*, and fine lines chiefly in the *red* and *green* spaces.

3. *Acetate of Strontites.* Colour of the flame yellow. Fine red and orange lines near D, and one fine *blue* line, and an extreme red.

4. *Acetate of Lime.* Flame *brown.* Many fine lines, and a large green and red one on each side of D.

5. *Chromate of Ammonia.* Fine *green* and *red* bands near D.

6. *Lithoxanthate of Ammonia.* Fine lines throughout the whole spectrum, with a fine *bright* blue band.

7. *Superacetate of Lime.* A fine *blue* line in the extreme violet; and an *orange* and *green* band equidistant from D.

8. *Tartrate of Potash* and *Antimony.* Flame brilliant *blue.* The extreme *red* finely insulated.

---

* Report of the British Association for 1842, p. 15.

9. *Cryolite.* Flame *yellow*, but green at top. Bright lines in the green, and a very remarkable and bright one in the yellow close to D. There are lines also in the *red*, and the *yellow* light is unusually copious.

10. *Muriate of Barytes.* Flame *green.* The lines splendid. *Two* in the *blue*, *two* in the *green*, *four* in the *yellowish green*, and *two* in the *red.*

3. On the Radiant Spectrum. By Sir David Brewster, K.H., F.R.S.

I have given the name of *Radiant Spectrum* to a phenomenon which I discovered in 1814, and which I described to this Society in the early part of that year.

It will be understood from fig. 1, which represents the brilliant radiation which surrounds a very small image of the sun, when it is formed either by reflection or refraction, or otherwise.

If we now form a spectrum of this radiant image, either by a prism or by diffraction, we shall have the *radiant spectrum* shown in fig 2, where MN is the spectrum of the small circular image S, and AB the spectrum of the radiation, the centre of which is beyond the violet, and nearly in the place where the intensity of the chemical or invisible rays is a *maximum*.

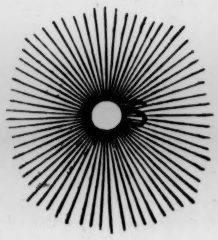


Fig. 1.

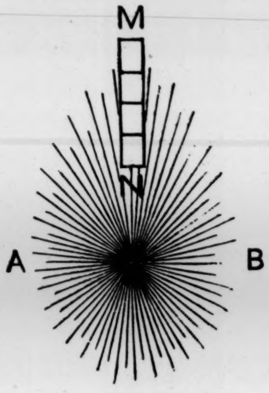


Fig. 2.

In order to analyse this compound radiation, let the image of the sun S, fig. 1, be taken from homogeneous *red* light R, fig. 3, and refracted by the prism, we shall have its radiation *ab* at a little distance from the bright portion R, as in fig. 3. In homogeneous *yellow* light Y, fig. 4, the radiation *ab* will be at a greater distance from Y than in the *red* light. In homogeneous *violet* light V, fig. 5, the radiation *ab* will be at a greater distance from V than in the *yellow* light.

If we now refract laterally these homogeneous radiant spectra, fig. 3 will be changed into fig. 6, fig. 4 into fig. 7, and fig. 5 into fig. 8, thus proving that the radiant portion of the spectra consists of rays more refrangible than the portion RY and V from which

Fig. 6.

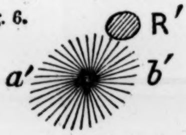


Fig. 3.

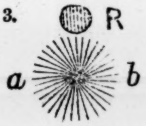


Fig. 7.

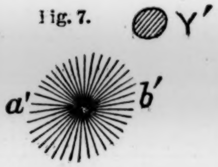


Fig. 4.

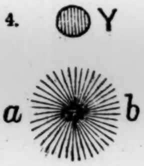


Fig. 8.

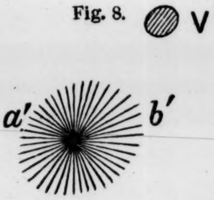


Fig. 5.

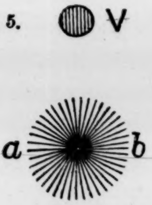
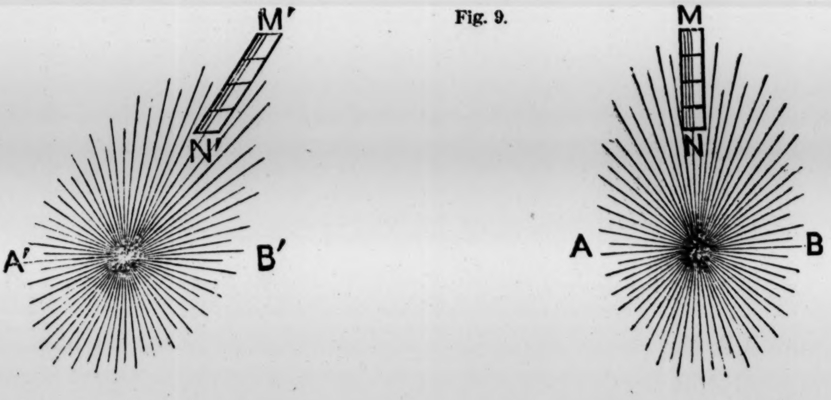


Fig. 9.



it is derived, and that the difference between the refractive indices of these portions increases with the refrangibility of the rays at RY and V.

The compound spectrum MN, AB, fig. 2, is therefore composed of all these separate spectra, and if we refract it laterally, as shown in fig. 9, we produce the oblique radiant spectrum M′N′A′B′, thus proving that the radiant image consists of rays more refrangible than the homogeneous light from which it is derived.

In a rude experiment with a prism of flint glass, whose mean index of refraction was 1·596, the index of the extreme violet was 1·610, and that of the centre of the radiant image 1·640.

In the preceding experiments the radiation is produced by the action, on the retina, of the small and bright image of the sun; but the same results are obtained, and more distinctly exhibited, by placing a surface of finely-ground glass either on the front of the prism, or behind it, and near the eye.

The existence of a radiant image beyond the violet end of the spectrum, as in fig. 2, is a fact difficult to explain. I have had an opportunity of describing, or showing it to several distinguished philosophers—to the Marquis Laplace and M. Biot in the autumn of 1814, and more recently to others, by some of whom the experiments have been repeated, but no explanation of them has been suggested, excepting the untenable one that the separation of the radiant image from the ordinary spectrum might be the result of parallax.

A better theory, and one of great interest, if true, may be sought in the phenomena of fluorescence, discovered in sulphate of quinine by Sir John Herschel, and in fluor spar and other substances by myself, and in the beautiful explanation of them by Professor Stokes. In this theory the invisible radiation of the chemical rays is rendered visible by being scattered by granular surfaces, just as the invisible chemical rays in the ordinary spectrum are rendered visible by being reflected and scattered by the particles of fluorescent bodies.

4. On the Vibration of a Uniform Straight Spring.

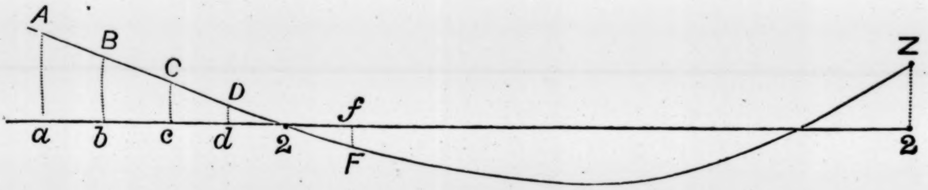
By Edward Sang, Esq.

In this paper the solution of the well-known and hitherto refractory problem, "to investigate the law of motion of a uniform elastic plate," is presented as an example of the application of the theory of primaries to physical research. This problem, on account of its importance in the theory of acoustics, has attracted the attention of the most celebrated mathematicians.

If we suppose a physical elastic line, flexible only in one plane, to have a number of masses fixed at intervals along it—if we investigate the law of the motions of these masses—and if, thereafter, we imagine the masses to be indefinitely subdivided and their parts distributed along the intervals, we shall arrive at the law of vibration of an elastic plate. Now, when we examine the general features of the vibration of such a discrete series, we discover that every motion of which it is susceptible may be regarded as the combination of simple movements, the number of which is equal to the number of the connecting ties; these simple movements being such that, if one of them existed alone, all the parts of the series would come simultaneously into their mean positions. The demonstration of this theorem is identic with that which was given in a paper on linear vibration read before the Society during the session 1856–57, and therefore omitted from the present paper. From this theorem it follows, that the trembling of a continuous spring must be composed of an infinity of simple vibrations, each of which is performed in its own peculiar periodic time. Hence our attention must be given to the characters of a simple vibration.

In order that a number of bodies may perform simultaneous oscillations, it is necessary that their tendencies to return to their mean positions be proportional to their distances from these positions, and to their masses jointly. Hence, if a number of equal masses be arranged uniformly along a thin elastic uniform bar, the form which that bar assumes when making a simple vibration must be such that the pressures necessary to retain it at rest in that shape are proportional to the distances from the mean position.

That is, the pressure at A must be proportional to the ordinate A*a*, the pressure at B to the ordinate B*b*, and so on. Now, if the ordinates A*a*, B*b*, C*c*, D*d*, &c., were in arithmetical progression, there would be no flexure at any of the points; the flexure is, in fact, proportional to the second difference of the ordinates; for example, the flexure at D is proportional to the second difference of the three ordinates C*c*, D*d*, E*e*, or to C*c* – 2D*d* + E*e*. Again, when a straight bar is slightly bent by pressures applied at three points, the flexures at equidistant intermediate points are in arithmetical progression; that is to say, if at the point D no pressure be applied, the flexure at D must be an arithmetical mean between those at C and E. When pressure is applied at D, that pressure must be proportional to the second difference of the flexures at C and E, and consequently to the fourth difference of the ordinates at B, C, D, E, and F.



Hence the characteristic property of the form assumed by such a discrete series when making a simple vibration is, that the length of any ordinate, as *d*D, must be proportional to the fourth difference of the five ordinates of which it is the middle one.

In passing from the discrete series of masses to the concrete bar, the differences of the various orders are replaced by the derivatives of the same orders, and hence the general character of the curve assumed by an elastic bar when making a simple vibration is this, "that the ordinate at any point of the curve is proportional to its fourth derivative, the abscissa being the primary;" and this statement contains the complete solution of the problem.

Putting x for the abscissa, and y for the ordinate, of the curve, the above proposition may be written

$${}_{4x}y = ky\,;$$

it indicates the relation between the function and one of its derivatives, thus bringing the problem under the dominion of the calculus of primaries; the object of that calculus being to discover the relation of the primary variable to the function, when the relation subsisting between that function and its derivative is known. It also shows that the function belongs to the class of recurring functions of the fourth order; and that, therefore, the equation

$$\phi x = y = \mathrm{A}\boxed{0}\frac{x}{l} + \mathrm{B}\boxed{1}\frac{x}{l} + \mathrm{C}\boxed{2}\frac{x}{l} + \mathrm{D}\boxed{3}\frac{x}{l}$$

represents the form of the curve in every possible case of simple vibration; A, B, C, D being coefficients, having fixed ratios to each other, and l being a length depending on the relation of the linear unit to the dimensions of the system.

It only remains to apply this general formula to particular cases. The end of an elastic bar may be held firmly as in a vice, it may be entirely free, and it may be touched, but without any angular tension; and these three conditions may be combined at the two ends of the bar, thus making in all six distinct cases, as under, viz.—

Case 1. When the elastic bar is held firmly by one end, the other end being free.
Case 2. When both ends are free.
Case 3. When both ends are held fast.
Case 4. When one end is free, the other touched.
Case 5. When one end is held, the other touched.
Case 6. When both ends are touched.

Now, when the end of the bar is held fast, both the ordinate and its derivative must be zero for that end; when the end is free, the second and third derivatives must be zeroes there; and lastly, when the end is touched without angular tension, the ordinate and its second derivative must each be zero; and therefore the peculiarities of the equations applicable to the various cases are easily found.

Case I.

In the first and most familiar case, when the elastic bar is held firmly by one end, it is easily shown that if X be the entire length, the zero being placed at the fixed end, we must have $A = 0$, $B = 0$, while the coefficients C and D must satisfy the two conditions

$$C\boxed{0}\frac{X}{l} + D\boxed{1}\frac{X}{l} = 0; \qquad C\boxed{3}\frac{X}{l} + D\boxed{0}\frac{X}{l} = 0;$$

which give

$$\boxed{0}\frac{X}{l} \cdot \boxed{0}\frac{X}{l} = \boxed{1}\frac{X}{l} \cdot \boxed{3}\frac{X}{l};$$

from which equation the ratio $\frac{X}{l}$ has to be determined.

Denoting this ratio by ρ_1, we observe that ρ_1 has an infinite number of values corresponding to the infinite number of simple vibrations of which the system is susceptible, and that the times of these vibrations are as the squares of the different values of l thence resulting. This general equation of condition may also be put into the form

$$\boxed{0}\rho_1^2 - \boxed{2}\rho_1^2 = -1;$$

and the equation of the curve becomes

$$y_1 = \boxed{1}\rho_1 \cdot \boxed{2}\frac{x}{l} - \boxed{0}\rho_1 \cdot \boxed{3}\frac{x}{l}.$$

CASE II.

When both ends of the bar are free.

In this case the equation of condition becomes

$$\boxed{2}\rho_2 \cdot \boxed{2}\rho_2 = \boxed{1}\rho_2 \cdot \boxed{3}\rho_2,$$

or

$$\boxed{0}\rho_2^2 - \boxed{2}\rho_2^2 = +1,$$

while that of the curve is

$$y_2 = \boxed{2}\rho_2 \cdot \boxed{0}\frac{x}{l} - \boxed{1}\rho_2 \cdot \boxed{1}\frac{x}{l}.$$

CASE III.

When both ends are held fast.

The equation of condition in this case is found to be identic with that of the preceding case, and hence we have this very remarkable law, that the sounds emitted by an elastic bar when suspended so as to vibrate freely, are identic in pitch with those given out by a similar bar of the same length held firmly at each end. The equation of the curve in this case is

$$y_3 = \boxed{2}\rho_2 \cdot \boxed{2}\frac{x}{l} - \boxed{1}\rho_2 \cdot \boxed{3}\frac{x}{l} \; .$$

Cases IV. and V.

are shown to be included in the two preceding; the touched extremity corresponding to the middles of the lengths in those cases when the node of the curve happens to be there.

Case VI.

In this case, when the ends are held, but without angular tension, the equation of condition is

$$\boxed{1}\frac{X}{l} - \boxed{3}\frac{X}{l} = 0 \, ,$$

but the difference between these two quaternary functions is the sine of $\frac{X}{l}$, and so the equation takes the familiar form

$$\sin \frac{X}{l} = 0 \; ,$$

and so $\frac{X}{l}$ has an infinity of values forming the arithmetical progression π, 2π, 3π, 4π, &c.; and the equation to the curve becomes

$$y_6 = \boxed{1}\frac{x}{l} - \boxed{3}\frac{x}{l} = \sin \frac{x}{l} \; ,$$

so that in vibrating, the bar takes the form of the curve of sines, and the nodes divide the whole length equally. In this case the rapidities of the different vibrations are as the squares of the series of natural numbers.

The determination of the numerical values of the coefficients in the other cases must be obtained by the solution of the transcendental equations

$$\boxed{0}\rho^2 - \boxed{2}\rho^2 = -\, 1, \text{ and } \boxed{0}\rho^2 - \boxed{2}\rho^2 = +\, 1 \; ,$$

and this solution is obtained in the following manner.

By putting θx to represent the complex function $\boxed{0}x^2 - \boxed{2}x^2$, and taking its successive derivatives, we obtain, for the fourth derivative, the result

$${}_{4x}\theta x = -\, 4\,\theta x \; ,$$

that is to say, the fourth derivative is quadruple of the function with the sign changed. This brings us to a new class of functions in reality of the eighth order, and bearing to the quaternary functions the same kind of relation which the circular functions, *cosine* and *sine*, bear to the catenarian ones.

If we write instead of x, $z\sqrt{\tfrac{1}{2}}$ we have

$$\boxed{0}x^2 - \boxed{2}x^2 = 1 - \frac{z^4}{\ldots 4} + \frac{z^8}{\ldots 8} - \text{etc.},$$

in which the signs are alternately $+$ and $-$; denoting this function by the character $\Diamond_0\, z$, and its derivatives by $-\Diamond_3\, z$, $-\Diamond_2\, z$, $-\Diamond_1\, z$, we have four functions, viz.,

$$\Diamond_0 z = 1 \quad - \frac{z^4}{\cdot\cdot 4} + \frac{z^8}{\ldots 8} \quad - \text{etc.},$$

$$\Diamond_1 z = \frac{z}{1} \quad - \frac{z^5}{\cdot\cdot 5} + \frac{z^9}{\ldots 9} \quad - \text{etc.},$$

$$\Diamond_2 z = \frac{z^2}{1.2} \quad - \frac{z^6}{\ldots 6} + \frac{z^{10}}{\ldots 10} \quad - \text{etc.},$$

$$\Diamond_3 z = \frac{z^3}{1.2.3} - \frac{z^7}{\ldots 7} + \frac{z^{11}}{\ldots . 11} - \text{etc.},$$

which are almost the counterparts of the quaternary functions, and of which the values may be computed with great ease. And it is noteworthy that by putting $z = v\sqrt{\tfrac{1}{2}}$, these functions reproduce the quaternary ones.

The determination of the values of the coefficients in the equations of the curve, is thus reduced to the numerical solution of the two equations

$$\Diamond_0 z = -1, \text{ and } \Diamond_0 z = +1,$$

and situated between these there is this, viz.,

$$\Diamond_0 z = 0,$$

the roots of which are the odd multiples of $\pi\sqrt{\tfrac{1}{2}}$.

The results of the calculation, as applied to the case of an elastic rod held firmly by one end, were stated to be, that the fundamental or slowest vibration, and the next one, have their periodic times in the ratio of 6·2557 to 1, or very nearly as 25 to 4. And that the node in the second vibration is at the distance ·78345 parts of the whole length from the fixed end. These results were confirmed by experiments made in the manner first shown by Professor Wheatstone.

The following Gentlemen were admitted Fellows of the Society:—

Charles Gainer, M.A., M.D., F.L.S.
William Keddie, Esq.

The following Donations to the Library were announced:—

Proceedings of the Royal Society, London. Vol. XV. No. 91. 8vo. —*From the Society.*

Proceedings of the Meteorological Society, London. Vol. III. Nos. 28, 29. 8vo.—*From the Society.*

Journal of the Linnean Society, London. Vol. IX. [Botany] No. 39. 8vo.—*From the Society.*

Journal of the Statistical Society of London. Vol. XXX. Part 1. 8vo.—*From the Society.*

Journal of the Chemical Society, London. April 1867. 8vo.—*From the Society.*

Twelfth Annual Report of the Registrar-General on the Births, Deaths, and Marriages registered in Scotland during the year 1866; and Second Annual Report on Vaccination (with Supplement). Edinburgh, 1867. 8vo.—*From the Registrar-General.*

Monthly Returns of the Births, Deaths, and Marriages registered in the Eight Principal Towns of Scotland. For February and March 1867. 8vo.—*From the Registrar-General.*

Mémoires de la Société des Sciences Physiques et Naturelles de Bourdeaux. Tome I.–IV. 8vo.—*From the Society.*

Bulletin de la Société de Géographie. Mars, 1867. 8vo.—*From the Society.*

Nachrichten von der Königlichen Gesellschaft der Wissenschaften und der Georg-Augusts-Universität aus dem Jahre 1866. Gottingen, 1866. 8vo.—*From the Society.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. October, November, December 1866. 4to.—*From the Geological Society of Vienna.*

Report of the Committee on Safety-Signals. Presented to the General Railroad Convention, held at New York, October 24, 1866. 8vo.—*From the Committee.*

Monatsbericht der Königlich Preussischen Akademie der Wissenschaften zu Berlin. December 1866. Berlin, 1867. 8vo.—*From the Academy.*

Monday, 29th April 1867.

Sir DAVID BREWSTER, President, in the Chair.

The following Communications were read:—

1. Description of a Double and Triple Holophote, and of a Method of Introducing the Electric and other Lights By Sir David Brewster, K.H., F.R.S.

2. On the Effect of Reduction of Temperature on the Coagulation of the Blood. By John Davy, M.D., F.R.SS. Lond. and Edin.

In an excellent little work recently published on elementary physiology,* its author, when treating of the blood and its coagulation, remarks that a low temperature retards its coagulation; and that "blood kept at the freezing-point of water will not coagulate at all." He adds: "Blood thus kept fluid will, however, coagulate when its temperature is raised; and blood has been thus cooled and warmed till near coagulation for three successive times without losing its coagulability."

That the lowering the temperature of the blood retards its coagulation is now unquestionable; but the statement that it does not coagulate at all at the freezing-point of water, is new to me. Not aware that it has been the subject of experimental inquiry, I thought it right to make some trials to endeavour to determine whether the blood can, indeed, be retained in its liquid form in the manner stated.

---

* Lessons on Elementary Physiology. By Thomas H. Huxley, LL.D., F.R.S. 1866.

The trials I have instituted have been of two kinds—one by receiving blood in a cooled vessel, cooled by snow, and kept in snow; the other, by receiving it in a vessel of low temperature in a freezing mixture of salt and snow, and, when frozen, transferring it to snow, with the intent to see whether, after thawing (the freezing-point of blood being lower than that of water) it would continue liquid or would coagulate.

The results of both trials—and they were more than once made—were negative. The blood used was that of the sheep, procured at the slaughter-house; the quantity (the subject of the experiment) half a cubic inch; and the vessels into which it was received, tubes of thin glass about half an inch in diameter.

So small a quantity of blood was employed on account of the greater facility of lowering its temperature, whether to the freezing-point of water, or to the lower degree requisite for the freezing of the blood itself.

As regards the first mode of trial, in each instance, the blood in snow, at a temperature of 32° or 33° F., was found coagulated in about a quarter of an hour. The coagulum was somewhat softer than had the coagulation been more rapid without any interference—*i. e.*, in about two minutes.

As regards the second mode of trial, the coagulum formed after the thawing of the frozen blood was also softer than common; and the more so, it seemed, the longer the blood had been kept in the frozen state previous to liquefaction, as if the fibrin had thus been rendered less contractile.

The parts of the quotation given, in which it is said that blood kept fluid at the freezing-point of water will coagulate when its temperature is raised, and may be "cooled and warmed till near coagulation for three or four successive times," I do not, I must confess, well comprehend.

That blood may be rapidly frozen in small quantity, and rapidly thawed, and this more than once, I ascertained many years ago;* and just now, using sheep's blood, I have had the results confirmed. In the space of one hour, a cubic inch of blood was frozen and liquefied four different times. The vessel in which it was first frozen was a thin drinking cup about two inches in diameter. For the sake of rapid effect, it had been kept some time previously in a freezing mixture; and the blood, as soon as liquefied, was poured into a tube similarly cooled in the same mixture, to be again frozen,—and so on in succession.

---

* Researches, Physiological and Anatomical, ii. p. 77.

These results, I need hardly remark, are little more than a confirmation of those obtained by Hewson nearly a century ago.*

3. Note on a former Paper on the Theory of Double Refraction. By A. R. Catton, M.A., Fellow of St John's College, Cambridge.

4. A Preliminary Notice of the Akazga Ordeal of West Africa, and of its Active Principle. By Thomas R. Fraser, M.D.

This ordeal poison is referred to in the works of Du Chaillu† and Winwood Reade;‡ and several of its toxic properties have been described by MM. Pecholier et Saintpierre.§ A few specimens were sent to this country in 1864 by the Rev. A. Bushnell of Baraka, and these were very kindly given to the author by Mr Thomson of Glasgow; and a further supply came from the same quarter in 1865. These gentlemen, and Dr Nassau of Bonita, supplied valuable and interesting information regarding its employment.

The poison is known in Africa as Akazga, Boundou (or M'Boundou), Ikaja, and Quai; Akazga being probably derived from *nkazga*, which signifies pain or hurt. It is used as an ordeal for the detection of real and superstitious crimes on the West Coast of Africa, in a large district which extends north and south of the equator, and many miles inland, and also in the adjacent island of Corisco.

---

* The Works of William Hewson, F.R.S. Edited by George Sullivan, F.R.S., p. 17.

† Explorations and Adventures in Equatorial Africa, 1861.

‡ Savage Africa, 1862.

§ Comptes Rendus, 1866, p. 809.

It is believed that several thousand persons are annually subjected to this method of trial, and that the fatal cases are about 50 per cent.

The Akazga arrived in bundles, which consisted of long, slender, and crooked stems, having their roots generally attached to them, but sometimes their leaf-bearing branches only, and containing also a very few complete plants, with roots, stem, and branches. The plant is usually about six feet in length; but some specimens were only four, and others as long as eight feet. The bark is yellowish orange, and in some parts light red, and it is frequently covered with a gray efflorescence. It adheres firmly to the stem, but may be readily detached, after exposure to a gentle heat for some days. Its internal surface is light brown. The space between the bark and the wood was found, in a few pieces, to be occupied by a large number of minute sparkling crystals; but it has not yet been determined whether these consist of a vegetable or mineral substance. The leaves are opposite and oval-accuminate in form; the apex frequently consisting of a linear prolongation more than an inch in length. From its general characters, the plant is supposed to belong to the Loganiaceæ, but the materials are insufficient to identify it.

By boiling the powdered bark with alcohol of 85 per cent., and distilling and evaporating the tincture, a brown shining extract is procured, weighing from 12 to 15 per cent. of the bark employed. It has a bitter, non-persistent taste, and, when treated with concentrated nitric acid, produces a brownish-yellow colour, which is not materially affected by heat, nor by solution of protochloride of tin. It is obvious that the active principle of Akazga is contained in this extract; and to separate it the following method has been adopted, after several attempts with various processes:—The extract is treated with a very dilute solution of tartaric acid, which removes 77 per cent., and filtered. The clear, yellowish-brown acid solution is shaken with successive portions of ether, so long as any colour is removed; and by this means also a small quantity of an aromatic oil is separated from it. After decantation, a solution of carbonate of sodium is added to the liquor, so long as it causes a nearly colourless, flocculent precipitate. It is again shaken with ether, which is decanted, and agitated with three successive portions of distilled water, and finally received in a bottle containing a dilute solution of tartaric acid, and shaken with it. As soon as the etherial solution is brought in contact with the acid, it becomes opalescent, but again assumes its normal appearance on agitation. This change is of some value, as indicating the frequency with which the alkaline solution should be treated with ether, as the milkiness, on contact with tartaric acid, is not produced when the former is exhausted. On reaching this stage the tartaric solution is exposed to a gentle heat—to free it completely from ether—filtered, and again treated with carbonate of sodium, by means of which a bulky, colourless, and flocculent precipitate is obtained. This is collected in a filter, washed, and dried, by exposure to a gentle heat for a short time, and then by the action of sulphuric acid *in vacuo.*

By this means a colourless, amorphous substance is obtained, which is the active principle of the Akazga poison, and which possesses the general properties of a vegetable alkaloid. About 10 grains may be separated from 500 grains of the powdered stem-bark, or 2 per cent. *Akazgia* is proposed as its name; and it is hoped that when the plant is described, if it has been previously unknown to science, Akazga will be adopted as its specific name, and thus the usual connection of nomenclature between the vegetable alkaloid and its source will be maintained.

Akazgia is soluble in about 60 parts of cold absolute alcohol; in about 16 parts of spirit, of 85 per cent.; in about 120 parts of anhydrous sulphuric ether; and in 13,000 parts of distilled water, at a temperature of 60° F. It is freely soluble in chloroform, in bisulphide of carbon, in benzole, and in sulphuric ether of specific gravity 0·735. It crystallises with difficulty, but it may be obtained in the form of minute prisms, by the slow evaporation of a solution in rectified spirit. An analysis of its platinum-salt, and a determination of its combining proportion with dry hydrochloric acid, yielded 290 in the former, and 293 in the latter, as the equivalent of Akazgia. When heated it becomes yellow, then melts, and gives off fumes of a pungent, disagreeable odour, and finally becomes charred, but leaves almost no residue if the heat be continued for a sufficient time. Its solutions have an alkaline reaction, and neutralise acids; and the salts are freely soluble in water, and have a very bitter, non-persistent taste. Concentrated nitric, hydrochloric, and sulphuric acids change its colour to brown, but these in a diluted state, as well as many of the organic acids, form pale, yellowish solutions with Akazgia. It is precipitated from these solutions by hydrate, carbonate, and bicarbonate of sodium, and of potassium; by iodide, sulphocyanate, ferrocyanide, and chromate of potassium; by phosphate of sodium, protochloride of tin, trichloride of gold, dichloride of platinum, potassio-mercuric-iodide, carbazotic acid, tincture of galls, solution of iodine, and various other substances, *but these precipitates are never crystalline.* Corrosive sublimate causes an amorphous white precipitate, which is dissolved by heat, and reappears in a non-crystalline form when the solution has cooled. Chlorine produces an amorphous, colourless precipitate, which does not disappear on the addition of ammonia. With concentrated sulphuric acid, and peroxide of manganese, bichromate of potassium, or any other of the usual oxidizing agents, the same succession of colours is produced, from blue to brown, which results from a similar treatment of strychnia.

The alcoholic extract of Akazga possess physiological properties very similar to those of nux vomica; and comparative experiments were detailed, to show that the active principle, Akazgia, has exactly the same actions as the extract, and a proportional activity to it.

There are several instances in which a Natural Order produces several very similar active principles. In the Loganiaceæ itself, strychnia, brucia, and igasuria already exist, and these are nearly identical in their physiological actions. In chemical properties, brucia and igasuria have much in common, and they are both readily distinguishable, in this respect, from strychnia. Akazgia conveniently completes this group, as its chemical properties are nearly allied to those of strychnia, whilst its connection with all the numbers is maintained by the similarity of its physiological actions.

5 On a Lower Limit to the Power exerted in the Function of Parturition. By J. Matthews Duncan, M.D.

In this paper the author's object was to show what propelling power was required and produced to push the fœtus through the passages into the world in the easiest deliveries. The fact chiefly founded on, as affording a basis for the necessary calculations, was the occasional birth of the ovum entire, that is, the membranes containing the fœtus and liquor amnii being entire after passing through the maternal passages. In such cases the strength of the amniotic membrane was greater than that of the parturient or expulsive power. The expulsive power was in them never so strong as to break the bag of membranes; and the tensile strength of the membrane being ascertained by experiment, the propelling power could be calculated from it.

In like manner, in labours in which the expulsive efforts merely ruptured the bag in the last pains, or did not increase in power after the rupture, the tensile strength of the membranes afforded, along with other data, the means of estimating with considerable certainty and exactness the effective force which completed the labour.

One hundred experiments were performed upon the fœtal membranes in many different cases, in order to acquire data for the calculations above referred to. In conducting them, Dr Duncan had the assistance of Professor Tait, who also pointed out the method of making the computations from the data acquired in them.

After experimentally ascertaining the tensile strength of the membranes, the power of the labour at the time of the rupture of the bag was found, and it was held that the lumen of the passage opened up by the advancing ovum was circular, and of 4½ inches in diameter, and that the bulge of the unsupported membrane was hemispherical. The force required to rupture the weakest amnion showed that the power of the labour was at least 4·08 lbs., that for the strongest 37·58 lbs.; and the average power indicated by the experiments on the amnion was 16·73 lbs.

It was interesting to point out that although the patient and a skilled observer might not remark any increased strength of labour as it advanced, yet, in consequence of the diminished dimensions of the uterine cavity, its muscular action, though the same, had greater effect or power.

Dr J. Poppel had made similar experiments, which anticipated some of the results of this paper. But his method of experimenting was open to the grave objection, that he always supposed the membrane to burst when in a hemispherical form—an error whose tendency is to make the strength of the membrane too little, and which may account for the difference between his results and those given in this paper.

Poppel experimented on the membranes of seven cases in which they burst "with the birth." In these cases, according to Poppel's method of calculating, and changing his results only so far as to make them comparable to those of this paper, the power terminating labour varied from about 6 to about 27 lbs.

The interesting result is thus arrived at, that in some of the easiest cases of labour the mere weight of the child, if duly applied, gives a force sufficient to effect delivery.

The average strength of the amnion found by Poppel, keeping in view an aperture of 2·5 inches in radius, was about 19 lbs.; by Dr Duncan, about 17 lbs.

Dr Duncan proceeded to show how an estimate could be formed of the force exerted in the most difficult labours spontaneously terminated. Joulin had stated it as about 100 lbs., while Dr Duncan believed it did not exceed 80 lbs.

Dr Duncan then observed that he knew of no method of ascertaining the powers of ordinary labours. But he described, though he did not recommend the use of, means by which it could be ascertained in any case. The essential part of this was the discovery of the pressure to which the pool of liquor amnii retained in utero after the rupture of the membranes was subjected as the labour progressed.

6. Some Mathematical Researches. By H. Fox Talbot, Esq.

7. On the Small Oscillations of Heterogeneous Interpenetrating Systems of Particles, which Act upon each other according to Laws dependent only on their Mutual Distaries. By A. R. Catton, M.A., Fellow of St John's College, Cambridge.

8. Note on a celebrated Geometrical Problem. By Professor Tait.

The following problem, originally proposed by Fermat to Torricelli, *To find the point the sum of whose distances from three given points is the least possible*, seems to have given considerable trouble to the older mathematicians, and even in modern times (see *Gregory's Examples*, p. 126) to have been solved in a very tedious manner. Simpler solutions have since been given (*e.g.*, *Cambridge and Dublin Mathematical Journal*, viii. p. 92), but none, to my knowledge, so direct as that indicated by Quaternions. The object of this note is to show the simplicity of the quaternion method.

If α, β be the vectors of two of the given points, the origin being the third, and if ρ be the vector of the required point, we must have (by the conditions of the problem)

$$\mathrm{T}\rho + \mathrm{T}(\alpha-\rho) + \mathrm{T}(\beta-\rho) \text{ a minimum.}$$

Hence

$$\mathrm{S}[\mathrm{U}\rho - \mathrm{U}(\alpha-\rho) - \mathrm{U}(\beta-\rho)]\, d\rho = 0,$$

for all values of $\mathrm{U}d\rho$. Hence the versor sum in square brackets must vanish identically. The immediate interpretation is, that *lines parallel to* ρ, $\rho-\alpha$, $\rho-\beta$, *form an equilateral triangle.* The required point is therefore in the same plane as the three given points; and their distances, two and two, subtend equal angles at it, which is the well-known solution.

Equally simple is the quaternion solution of the same problem if more points than three be given. Let their vectors, to any origin, be α, β, γ, &c., and let ρ be the vector of the sought point. We have

$$\Sigma \,.\, T(\alpha - \rho) = \text{minimum},$$

from which, as above,

$$\Sigma U(\alpha - \rho) = 0. \quad . \quad . \quad . \quad . \qquad (1.)$$

Hence, *if unit forces act at the required point, in the lines joining it with the given points, these forces are in equilibrium.* Or, in another form, *a closed equilateral gauche polygon may be drawn whose sides are parallel to the lines joining the sought points with the given ones.* This opens up some very curious geometrical speculations, which I have not time to pursue.

That there is but one point whose vector satisfies equation (1) may easily be proved by quaternions, but even more easily by the following reasoning. Consider the system of unit-forces, just mentioned, at any *two* points, one of which satisfies the problem. It is obvious that, if these forces be referred to the line joining the two points, each will be less inclined to it at one than at the other; so that, as at one they produce equilibrium, at the other they must have a finite component in the direction of this line.

The quaternion investigation at once suggests the following kinematical solution of the problem. Suppose an inextensible string to be passed through a small movable ring, then through small rings at two of the fixed points, then again through the movable ring, and so on—one end of the string being fixed to the movable ring when the number of given points is odd, and to the first fixed ring when the number is even. When the string is drawn tight, *i.e.*, when the sum of the lengths joining each fixed ring to the movable one is a minimum, the movable ring will evidently be in the position of the required point. Also, since the tension of the cord is the same throughout, the movable ring is kept in equilibrium by a set of equal forces in the directions of the lines joining it with the given points, which is the condition above found.

This kinematical process, equally with the quaternion one, whose form directly suggests it, gives easily the solution of the more general problem,—To find a point such that *m* times its distance from A, together with *n* times its distance from B, &c., may be a minimum.

9. On Vortex Motion. By Professor Sir William Thomson.

10. Note on the Radiant Spectrum. By Professor Tait.

This was a preliminary notice of a set of experiments, then in progress under very unfavourable circumstances, on the rare occasions when a ray of sunlight was procurable. The production of the phenomenon was traced to the peculiar texture of the membrane covering the cornea. The dependence of the whole on parallax was confirmed by the appearance of the radiant spectrum in precisely the same position with reference to the bright spectrum, when it was produced artificially by interposing a plate of slightly ground glass in the course of the light, so long as this plate was sufficiently near the eye to produce the phenomenon at all. A farther confirmation was given by the fact that, if the eye be near the prism, the appearance is the same on whichever side of the prism the ground glass be placed. The effects of achromatic prisms, of absorption by coloured glasses, and of the use of various kinds of homogeneous light taken from a pure spectrum, were also described.

11. Note upon a Method of varying Weights by Minute Quantities. By J. A. Broun, F.R.S.

A notice of a Gravimeter, proposed by me, appeared in the Proceedings of the Royal Society of Edinburgh early in 1861. The instrument, with various modifications, was forwarded to me in India about three years thereafter, and was found to have several imperfections which could have been corrected only by my own supervision of the work as it proceeded. His Highness the Rajah of Travancore has been good enough to sanction a sum of money for the construction of a second instrument, with all the precautions experience has suggested.

There are two methods by which the observations may be made. One, by which there is a constant angle of torsion of a single wire giving a variable angular movement to the weight suspended by two wires (depending on the force of gravity at the place of observation). The other, by which the weight suspended is varied, and the angles of torsion of the single wire and movement of the weight are constant. This second method I had at first rejected, as experience had shown me the difficulty of changing the weights without affecting the stability of the instrument. I desire now to note that I devised, about a year ago, and communicated to different men of science, a method of varying the weight, suspended with the greatest delicacy, and without jar to the instrument. This method consists in suspending from the weight a metallic wire, which enters a piece of barometer tube fixed below the instrument: by means of a screw entering a cistern below the tube, mercury (or another fluid, can be forced into the tube so as to immerse the metallic wire in the fluid; the wire being properly chosen as to fineness, or as to its specific gravity compared with that of the fluid, and the height of the fluid being read to a thousandth of an inch as in the barometer, the weight suspended can be made, by turning the cistern-screw, to vary gently and gradually, by as minute a quantity as we please; while the eye is occupied with the coincidences of the telescope wire and its images, which indicate the constancy of the angles of torsion of the single and double wires.

Although the difference of the specific gravities is considerable, I propose to employ iron for the wire and mercury for the fluid.

It has occurred to me that this method of varying a weight might be of use in other branches of research.

12. On the Diurnal Variation of the Magnetic Declination near the Magnetic Equator, and in both Hemispheres. By John Allan Broun, F.R.S., late Director of the Observatory of His Highness the Maharajah of Travancore, G.C.S.I., at Trevandrum.

The following Gentlemen were elected Fellows of the Society:—

J. F. M'Lennan, Esq., Advocate.
Rev. W. Lindsay Alexander, D.D.

The following Donations to the Library were announced:—

National Manuscripts, from William the Conqueror to Queen Anne, selected under the direction of the Master of the Rolls, and photozincographed by command of H.M. Queen Victoria, by Colonel Sir Henry James, R.E. Parts 1 and 2. Southampton, 1865. Fol.—*From the Ordnance Survey.*

The Life, Times, and Scientific Labours of the Second Marquis of Worcester. By Henry Dircks, C.E. London, 1865. 8vo.—*From the Author.*

Worcesteriana: a Collection of Literary Authorities, affording Historical, Biographical, and other Notices relating to Edward Somerset, Sixth Earl and Second Marquis of Worcester. By Henry Dircks, C.E. London, 1866. 8vo.—*From the Author.*

Three Centuries of Perpetual Motion. By Henry Dircks, C.E. London, 1861. 8vo.—*From the Author.*

Life of Samuel Hartlib, Account of his Publications, and Reprint of an Invention of Engines of Motion. By Henry Dircks, C.E. London, 1865. 8vo.—*From the Author.*

The Ghost, as produced in the Spectre Drama, popularly illustrating the Marvellous Optical Illusions obtained by the Apparatus called the Dircksian Phantasmagoria. By Henry Dircks, C.E. London, 1864. 8vo.—*From the Author.*

Contribution towards a History of Electro-Metallurgy, establishing the Origin of the Art. By Henry Dircks. London, 1863. 8vo.—*From the Author.*

American Journal of Science and Arts. No. 128 New Haven, 1867. 8vo.—*From the Editors.*

Bulletin de l'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique. No. 3. Bruxelles, 1867. 8vo.—*From the Academy.*

Journal of the Chemical Society. Nos. 52, 53, 54. London, 1867. 8vo.—*From the Society.*

Comptes Rendus for 1866–67, etc.—*From the Academy of Sciences, Paris.*

Journal of the Royal Society of Arts, London, for 1866–67. 8vo. —*From the Society.*

Monthly Notices of the Royal Astronomical Society, London, for 1866–67. 8vo.—*From the Society.*

Proceedings of the Society of Antiquaries of London. Vol. III. Nos. 1 and 2. London, 1865. 8vo.—*From the Society.*

Archæologia, or Miscellaneous Tracts relating to Antiquity. Vol. XL. London, 1866. 4to.—*From the Society of Antiquaries of London.*

Memoirs of the Geological Survey of India. Vol. V. Parts 2 and 3. Calcutta, 1866. 8vo.—*From the Survey.*

Palæontologia Indica. Vol. II. Parts 10–13. Calcutta, 1866. 4to.—*From the Geological Survey of India.*

Annual Report of the Geological Survey of India, and of the Museum of Geology, Calcutta, for 1865–66. 8vo.—*From the Survey.*

Catalogue of the Meteorites in the Museum of the Geological Survey of India. Calcutta, 1866. 8vo.—*From the Survey.*

Catalogue of the Organic Remains belonging to the Cephalopoda, in the Museum of the Geological Survey of India. Calcutta, 1866. 8vo.—*From the Survey.*

Astronomical and Meteorological Observations made at the United States Naval Observatory during 1864. Washington, 1866. 4to.—*From the Observatory.*

Journal of the Asiatic Society of Bengal. Part I. No. 3, 1866. Part II. No. 3, 1866. Calcutta. 8vo.—*From the Society.*

Proceedings of the Royal Society, London. No. 92. 8vo.—*From the Society.*

Proceedings of the Royal Geographical Society, London. Vol. IX. No. 2. 8vo.—*From the Society.*

Proceedings of the Meteorological Society, London. Vol. III. No. 30. 8vo.—*From the Society.*

Proceedings of the Royal Medical and Chirurgical Society of London. Vol. V. No. 17. 8vo.—*From the Society.*

Report of the Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire for 1865–66. Leeds, 1867. 8vo.—*From the Society.*

Report of the Professor of Astronomy in the University of Glasgow for 1867. Glasgow, 1867. 8vo.—*From the Observatory.*

November Meteors of 1866, as observed at the United States Naval Observatory, Washington. 8vo—*From the Observatory.*

Quarterly Return of the Births, Deaths, and Marriages registered in the Divisions, Counties, and Districts of Scotland. March 1867. Edinburgh, 1867. 8vo.—*From the Registrar-General.*

Monthly Return of the same for April 1867. Edinburgh, 1867. 8vo.—*From the Registrar-General.*

Die Fortschritte der Physik im Jahre, 1864; dargestellt von der Physikalischen Gesellschaft zu Berlin. Jahrgang, XX. Abtheilung, 1–2. Berlin, 1866–67. 8vo.—*From the Physical Society of Berlin.*

Monatsbericht der Königlich Preussischen Akademie der Wissenschaften zu Berlin. Jan.–Feb. 1867. Berlin, 1667. 8vo. —*From the Academy.*

Sitzungsberichte der Königl. bayer. Akademie der Wissenschaften zu München. Band. II. Heft 2, 3, 4. München, 1866. 8vo. —*From the Academy.*

Annales des Mines. Tome X. Liv. 4–5. Paris, 1866. 8vo.—*From the Ecole des Mines.*

Bulletin de la Société de Géographie. Avril 1867. Paris, 1867. 8vo.—*From the Society.*

Atti dell' Accademia Gioenia di Scienze Naturali. Tomo XX. Catania, 1865. 4to.—*From the Academy.*

Atti dell' Imp. Reg. Istituto Veneto di Scienze, Lettere ed Arti. Tomo XI. Dispensa 5–10; Tom. XII. Dispensa 1–3. Venezia. 8vo.—*From the Institute.*

Biografia di Carlo Gemmellara. Par Salvator Brancaleone. Catania, 1866. 8vo.—*From the Author.*

Della Natura del Colera Asiatico. Memoria del Dott. Filippo Pacini. Firenze, 1866. 8vo.—*From the Author.*

Bulletin de la Société Protectrice des Animaux. Mars 1867. Paris, 1867. 8vo.—*From the Society.*

Novorum Actorum Academiæ Cæsareæ Leopoldino-Carolinæ Germanicæ Naturæ Curiosorum. Vol. XXXII. Part 2. Dresdæ, 1867. 4to.—*From the Academy.*

Oversigt over det Kongelige danske Videnskabernes Selskabs Forhandlinger og dets Medlemmers Arbeider i Aaret 1865. Nr. 1, 2, 3, 4; 1866, 1, 2, 3, 4, 5, 6; 1867, 1, 2, 3. Kjobenhavn. 8vo.—*From the Academy of Sciences, Copenhagen.*

Memoires de la Société Impériale des Sciences Naturelles de Cherbourg. Tome XI., XII. 8vo.—*From the Society.*

Verhandlungen der Kaiserlich-Königlichen Zoologisch-botanischen Gesellschaft in Wien. Band XVI. Wien, 1866. 8vo.—*From the Royal Society of Vienna.*

Contribuzione pella Fauna dei Molluschi Dalmati, per Spiridione Brusina. Vienna, 1866. 8vo.—*From the same.*

Nachträge zur Flora von Nieder-Oesterreich von Dr August Neilreich. Vienna, 1866. 8vo.—*From the same.*

Bulletin de l'Académie Royal des Sciences, des Lettres, et des Beaux-Arts de Belgique. No. 4. Bruxelles, 1867. 8vo.—*From the Academy.*

Preisschriften gekrönt und Herausgegeben von der Fürstlich Jablonowskischen Gesellschaft zu Leipzig. 1867. 8vo.—*From the Royal Saxon Academy.*

Bulletin de la Société Vaudoise des Sciences Naturelles. Vol. IX. No. 55, 56. Lausanne, 1866. 8vo.—*From the Society.*

Die Kosmischen Abkühlungen ein Meteorologisches Prinzip von Dr Franz Octav Sofka. Mèn, 1863. 8vo.—*From the Author.*

Pinetum Britannicum. Parts XXII.-XXIV. Fol.—*From Charles Lawson, Esq.*

Quarterly Journal of the Geological Society. No. 90. London, 1867. 8vo.—*From the Society.*

Canadian Journal of Industry, Science, and Art. No. 63. Toronto, 1867. 8vo.—*From the Canadian Institute.*

Journal of the Royal Institution of Cornwall, with the Forty-ninth Annual Report. No. 7. 8vo.—*From the Institution.*

Proceedings of the Royal Asiatic Society of Bengal, from May to December 1866. January 1867. Calcutta. 8vo.—*From the Society.*

On the Scientific Premonitions of the Ancients. No. 1. Greek Geology. By John Young, M.D., Professor of Nat. Hist., Glasgow. 8vo.—*From the Author.*

Monday, 18*th March* 1867.

PAGE

On the Application of Relative, or Proportional, Equality to International Organisation. By Prof. Lorimer, . 113

On the Sophists of the Fifth Century, B.C. By Professor Blackie, ... 119

An Account of some peculiarly-shaped Mineral Concretions found near Carlisle. By Henry Barnes, M.D. Communicated by Sir David Brewster, . . 120

Note on Professor Tait's "Quaternion Path" to Determinants of the Third Order. By the Rev. Hugh Martin, M.A. Communicated by Professor Kelland, ... 121

Donations to the Library, ... 125

Monday, 1*st April* 1867.

On the Analysis of Compound Ethers. By W. Dittmar, 126

On a Derivative of Meconic Acid. By Messrs James Dewar and William Dittmar, ... 129

On the Action of Ammonia on Dichloracetone. By Dr A. Crum Brown, ... 133

On Centres, Faisceaux, and Envelopes of Homology. By Rev. Hugh Martin, M.A. Communicated by Professor Kelland, ... 134

On the Effect of Pressure upon Rock Salt and Iceland Spar. By M. Reusch, Professor of Natural Philosophy in the University of Tubingen. Communicated by Sir David Brewster, ... 134

Donations to the Library, ... 139

Monday, 15*th April* 1867.

On the Nature and Character of European Winter Storms, with the best means of giving Warning of their Approach. By R. Russell, Esq., . . . 140

On the Vapour Lines in the Spectrum. By Sir David Brewster, K.H., F.R.S., ... 145

On the Radiant Spectrum. By Sir David Brewster, K.H., F.R.S., ... 147

On the Vibration of a Uniform Straight Spring. By Edward Sang, Esq., ... 150

Donations to the Library, ... 156

Monday, 29*th April* 1867.

Description of a Double and Triple Holophote, and of a Method of Introducing the Electric and other Lights. By Sir David Brewster, K.H., F.R.S. . . 157

PAGE

On the Effect of Reduction of Temperature on the Coagulation of the Blood. By JOHN DAVY, M.D., F.R.SS. Lond. and Edin., ... 157

Note on a former Paper on the Theory of Double Refraction. By A. R. CATTON, M.A., Fellow of St John's College, Cambridge, ... 159

A Preliminary Notice of the Akazga Ordeal of West Africa, and of its Active Principle. By THOMAS R. FRASER, M.D., ... 159

On a Lower Limit to the Power exerted in the Function of Parturition. By J. MATTHEWS DUNCAN, M.D., . 163

Some Mathematical Researches. By H. FOX TALBOT, Esq., ... 165

On the Small Oscillations of Heterogeneous Interpenetrating Systems of Particles, which Act upon each other according to Laws dependent only on their Mutual Distaries. By A. R. CATTON, M.A., Fellow of St John's College, Cambridge, . . . 165

Note on a celebrated Geometrical Problem. By PROFESSOR TAIT, ... 165

On Vortex Motion. By Professor Sir WILLIAM THOMSON, 167

Note on the Radiant Spectrum. By Professor TAIT, . 167

Note upon a Method of varying Weights by Minute Quantities. By J. A. BROUN, F.R.S., . . . 167

On the Diurnal Variation of the Magnetic Declination near the Magnetic Equator, and in both Hemispheres. By JOHN ALLAN BROUN, F.R.S., late Director of the Observatory of His Highness the Maharajah of Travancore, G.C.S.I., at Trevandrum. . . . 168

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

SESSION 1867–68.

CONTENTS.

Monday, 2d December 1867.

PAGE

Opening Address. Session 1867–68. By Sir David Brewster, President. Communicated by Professor Kelland, ... 174

Donations to the Library, ... 205

Monday, 16th December 1867.

On Polyzomal Curves, &c. By Professor Cayley, . 217

Note on the Hodograph. By Professor Tait, . . 221

On the Antiquity of Intellectual Man: from a Practical and Astronomical point of view. By Professor C. Piazzi Smyth, ... 226

Monday, 6th January 1868.

On the Changes produced by direct Chemical Addition on the Physiological Action of certain Poisons. By Drs A. Crum Brown and Thomas R. Fraser, . . 228

On the Burning Mirrors of Archimedes, and on the Concentration of Light produced by Reflectors. By John Scott, Esq. Communicated by Professor Kelland, 232

[*Turn over.*

PAGE
On the Great Pyramid of Gizeh, and Professor C. P. Smyth's Views concerning it. By A. D. Wackerbarth, A.M., of Upsala. Communicated by Professor Kelland, ... 235
On the best Arrangement for producing a Pure Spectrum on a Screen. By J. Clerk Maxwell, M.A., F.R.SS. L. & E., ... 238

Monday, 20th January 1868.

Pyramidal Structures in Egypt and elsewhere; and the Objects of their Erection. By Sir J. Y. Simpson, Bart., ... 243
Note on the Occasional Occurrence of the Musculus Rectus Thoracis in Man. By Professor Turner, . . 268

Monday, 3d February 1868.

Address, at the request of the Council, delivered by the Rev. H. B. Tristram on the Recent Scientific Researches in Palestine, ... 271

Monday, 17th February 1868.

Obituary Notices of Dr Burt and Sir David Brewster. By Professor Playfair, ... 282
Observations relative to the Desirableness of Transporting from Alexandria to Britain the prostrate Obelisk presented to George IV. by Mahomed Ali Pacha. By Colonel Sir J. E. Alexander, K.C.L.S., . . 284
On the Temperature of the Common Fowl (*Gallus domesticus*). By the late Dr John Davy. Communicated by Professor Allman, . . . 288
Note on an Inequality. By Professor Tait, . 292

Monday, 2d March 1868.

Observations on the Spores of Cryptogamic Plants, and on the Reproductive Process in some Algæ and Fungi. By Professor Balfour, ... 294
Note on a Recent High Tide on the East Coast of Britain. By George Robertson, M. Inst. C.E. (Plate), 296

[*For continuation of Contents, see p.* 3 *of Cover.*